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Melancon

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(54) **BLOWOUT PREVENTER WITH WEDGE RAM ASSEMBLY AND METHOD OF USING SAME**

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(51) **Int. Cl.**
E21B 33/06 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 33/063*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 33/06; E21B 33/061; E21B 33/062; E21B 33/063; E21B 33/064
See application file for complete search history.

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(57) **ABSTRACT**

A ram assembly of a blowout prevent (BOP) includes a ram shuttle, a ram wedge and a ram seat. The ram shuttle and the ram wedge are slidably positionable in a ram channel of a BOP housing between a retracted and extended position. The ram shuttle has a wedge cavity extending therethrough and an inclined surface thereon. The ram wedge has a tubular cavity therethrough for receiving the tubular. The ram wedge has a corresponding inclined surface engageable with the inclined surface of the ram shuttle, and wedges between the ram shuttle and the housing whereby a force is generated therebetween. The ram seat is positionable in the housing about the passage, and is engageable with the ram wedge and the housing when the ram shuttle and the ram wedge are moved to the extended position whereby a seal is formed therebetween.

21 Claims, 22 Drawing Sheets

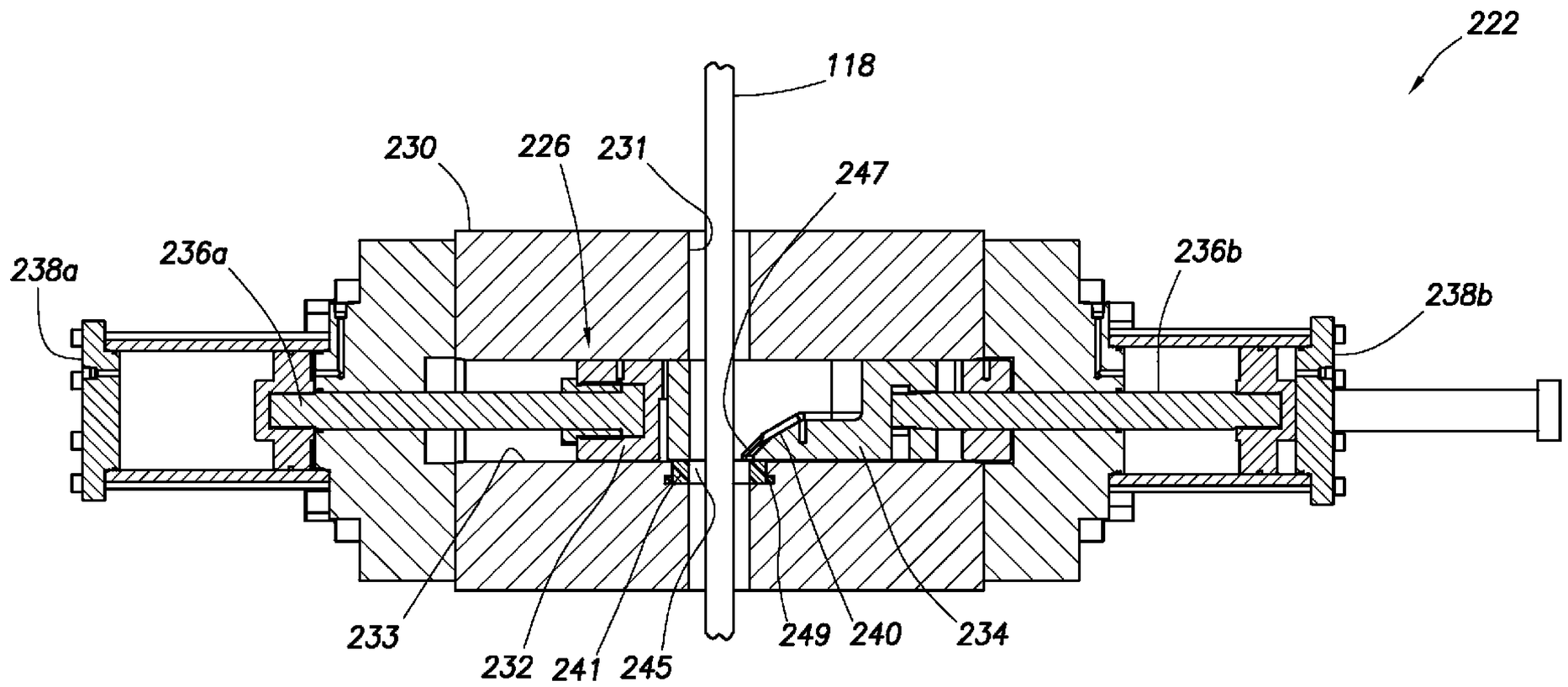

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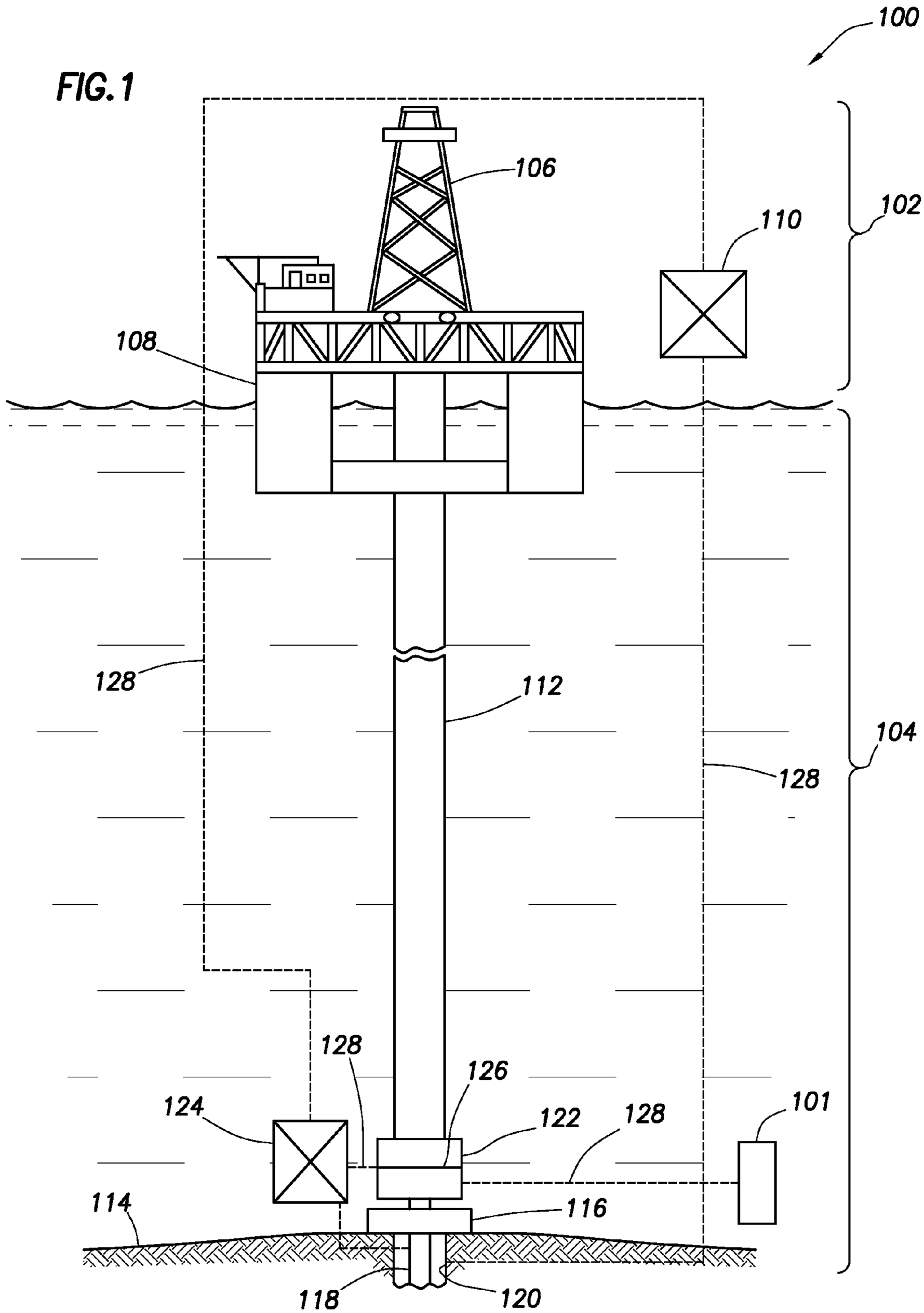
FIG. 1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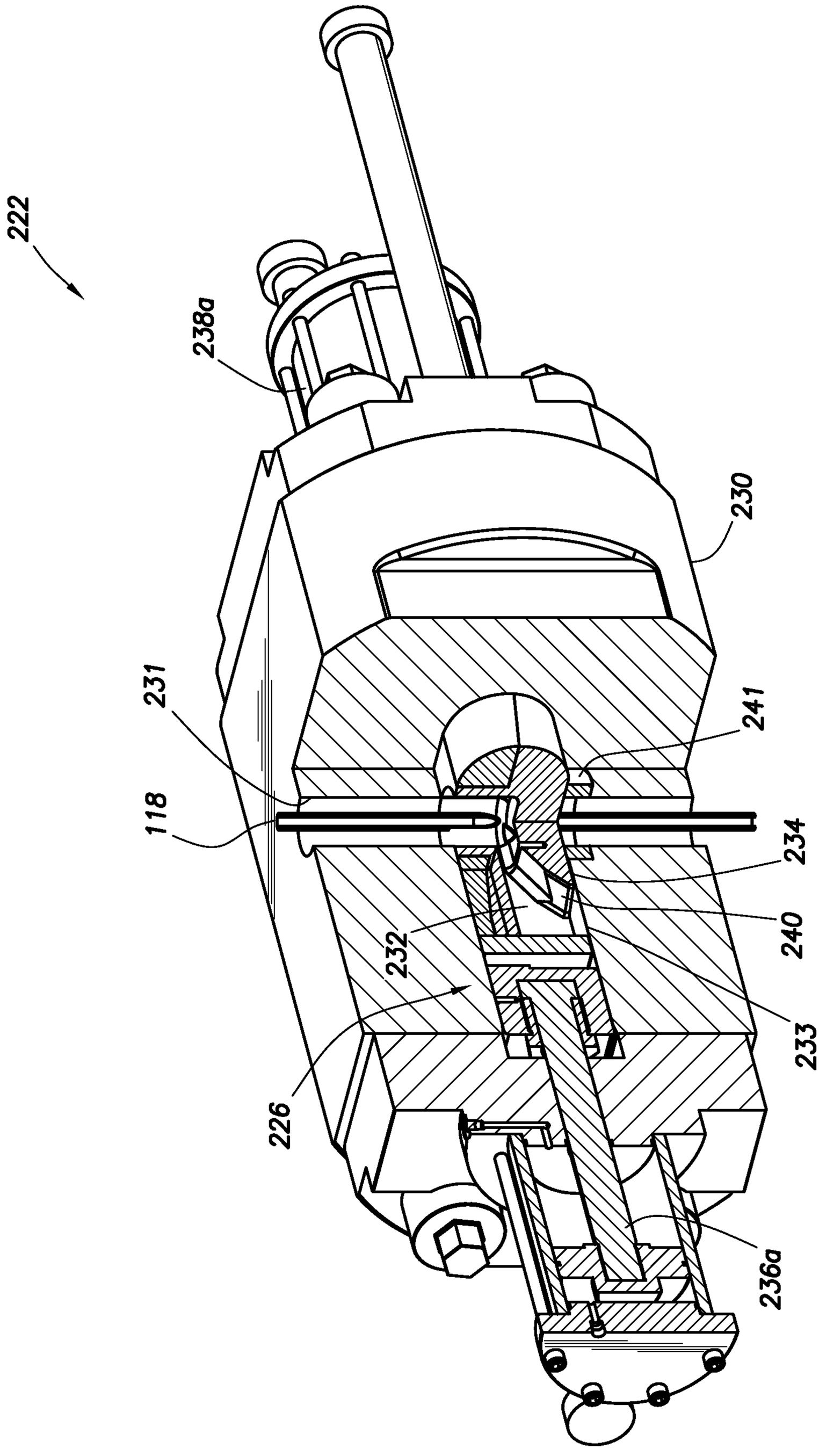


FIG.2

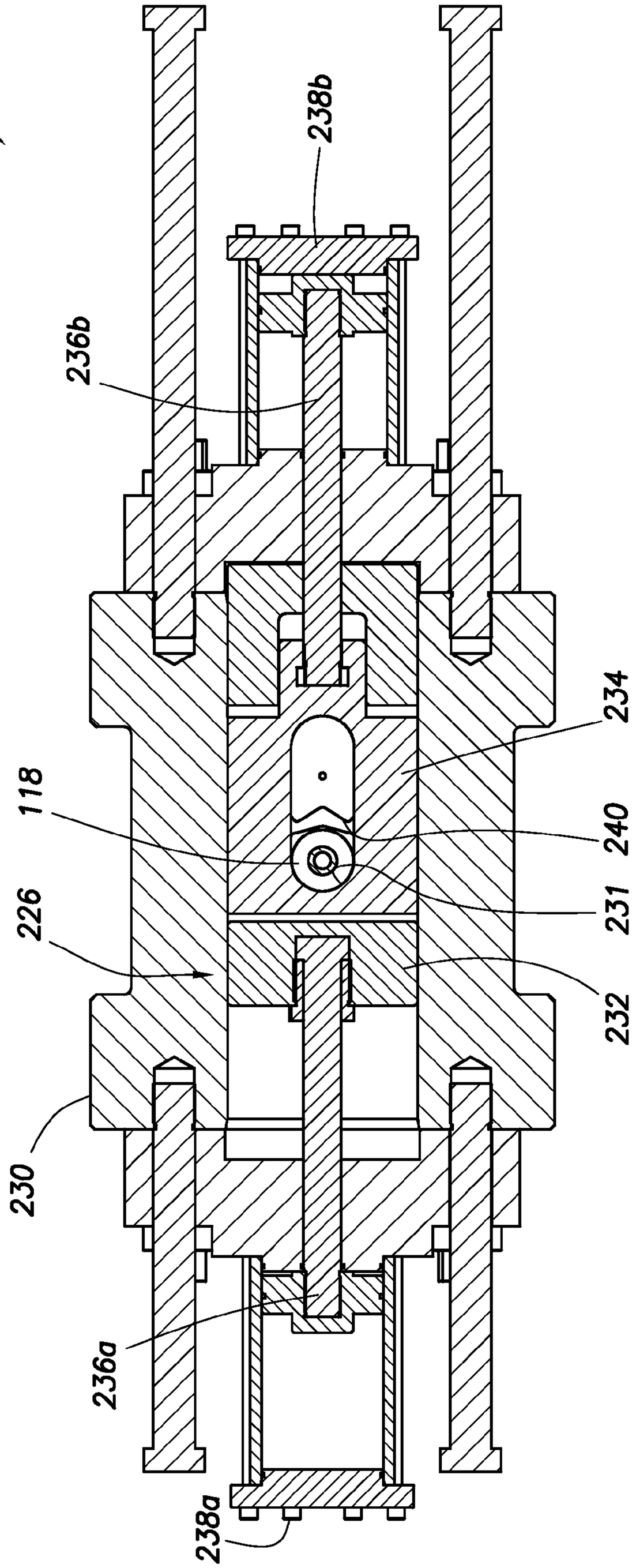
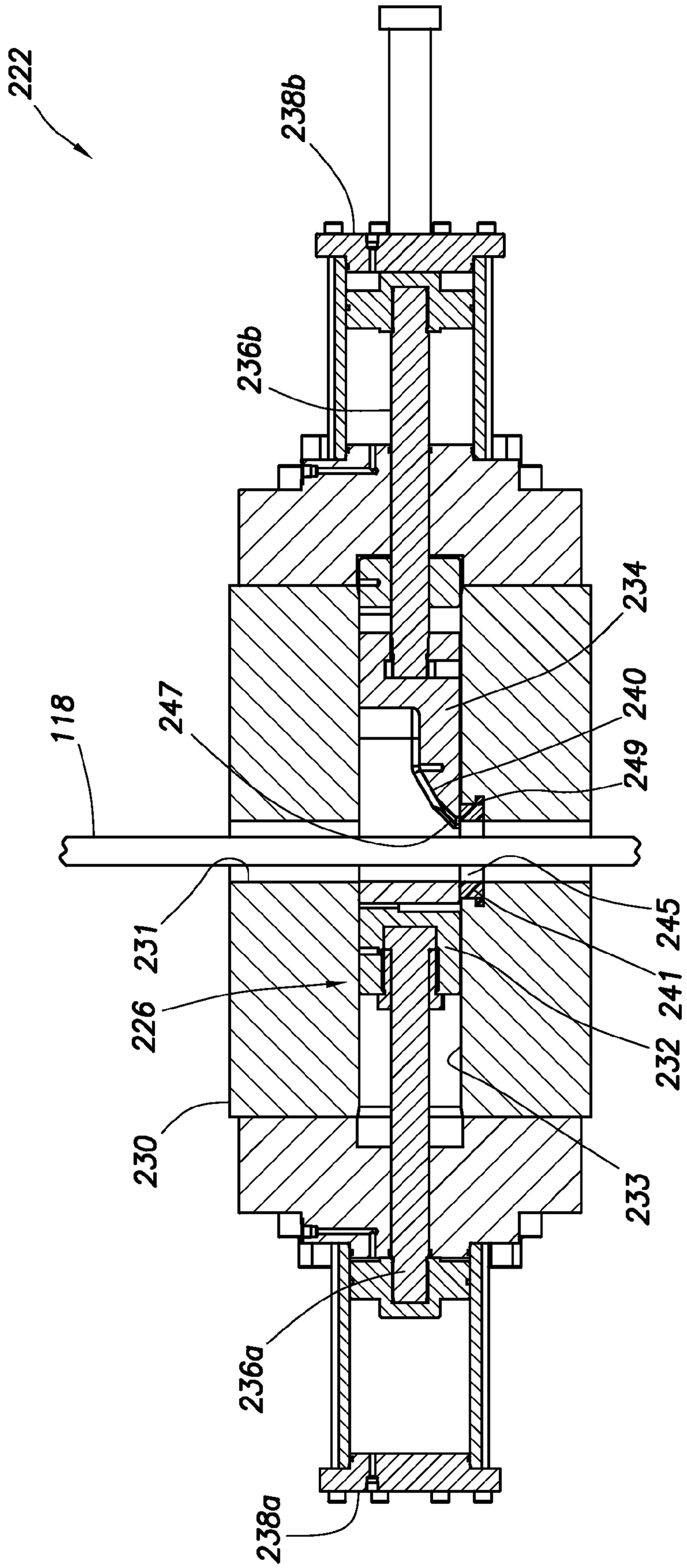


FIG.3A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231
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232
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FIG.3B

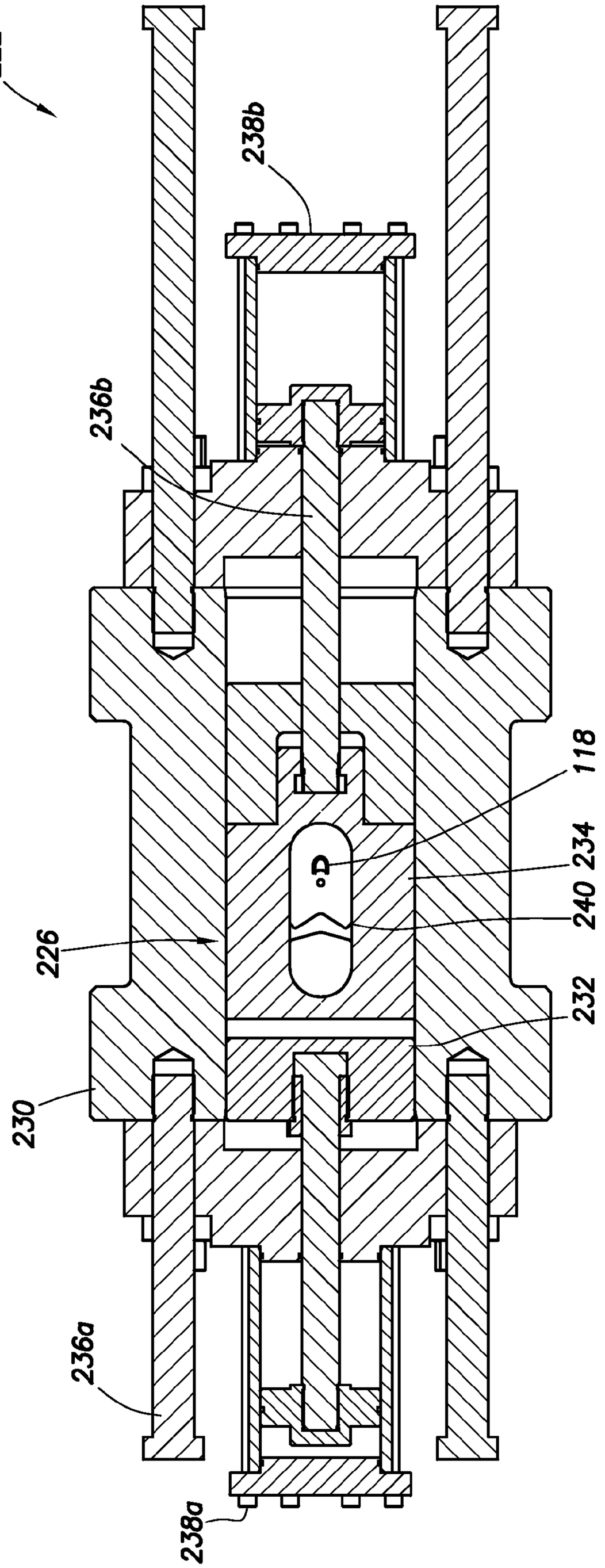

FIG. 4A

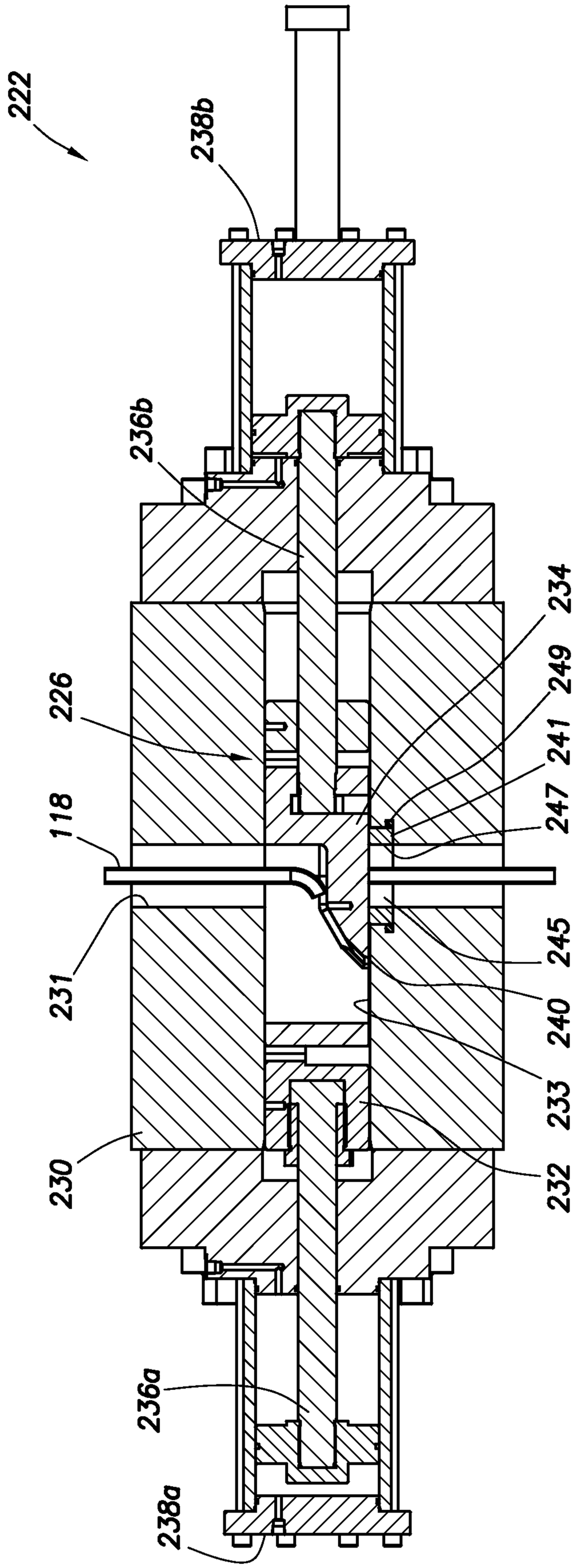
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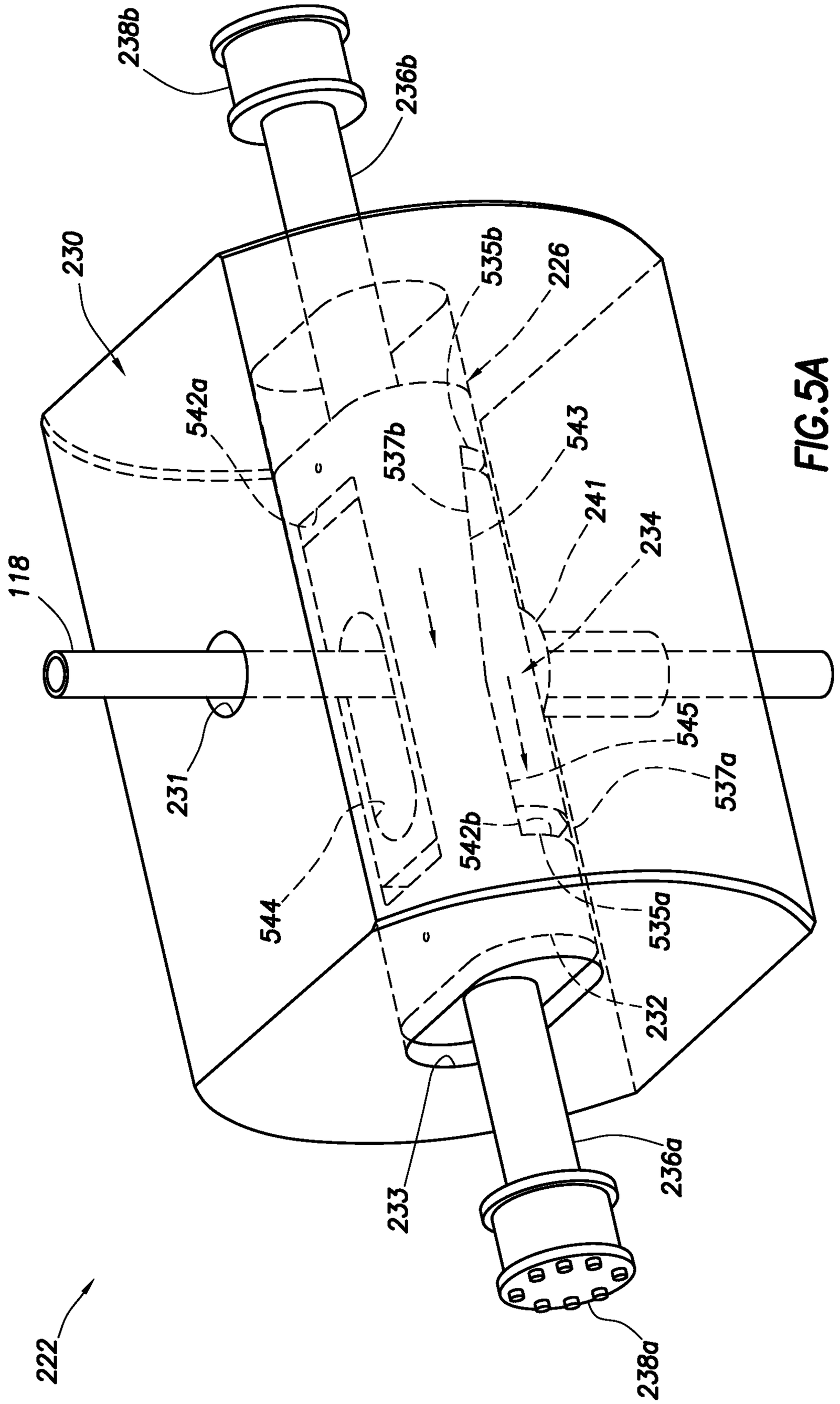
FIG.4B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236b
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226
542a
537b
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537a
544
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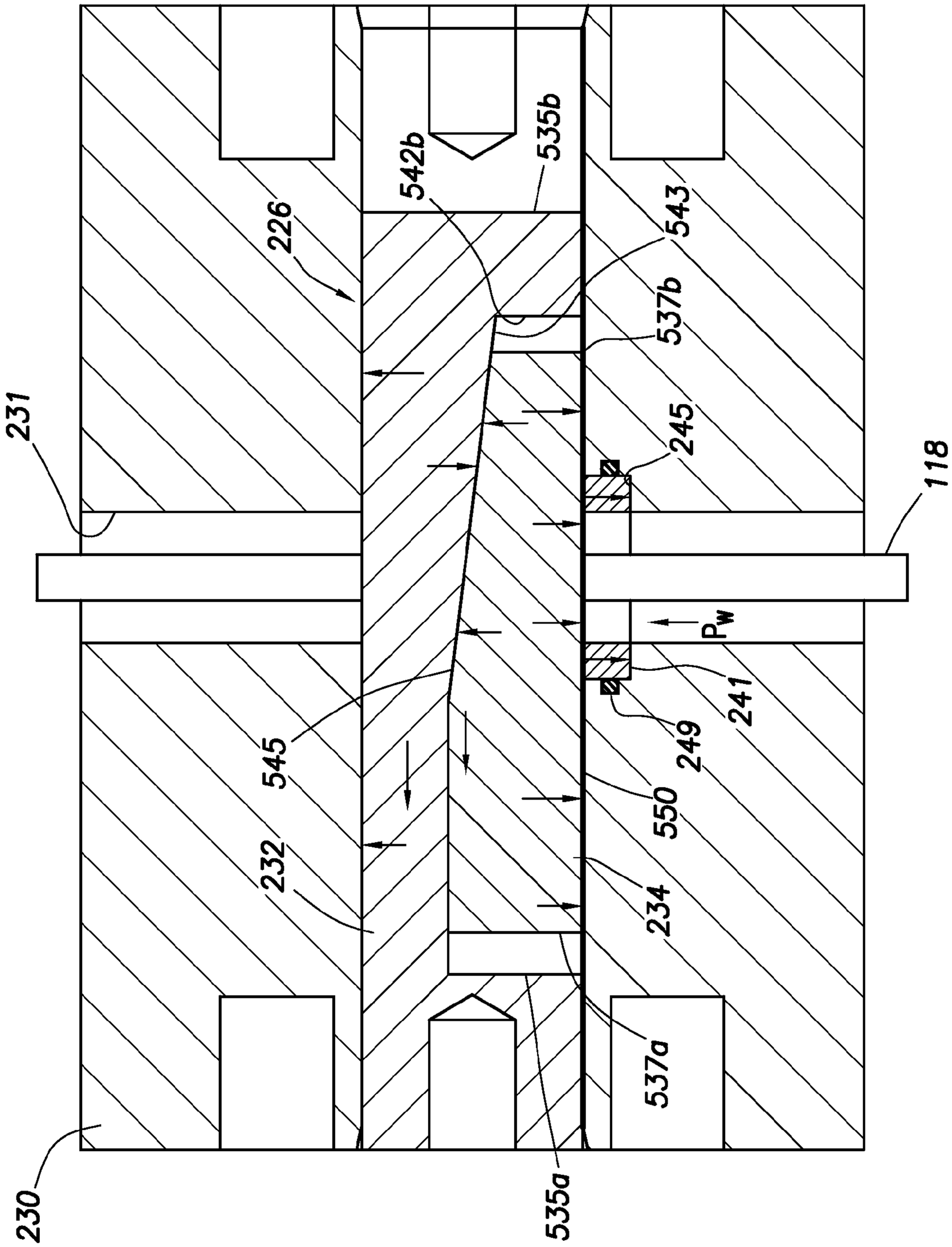
535a
232
233
236a
238a
222

FIG.5A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118
P_w
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535a

FIG.5B

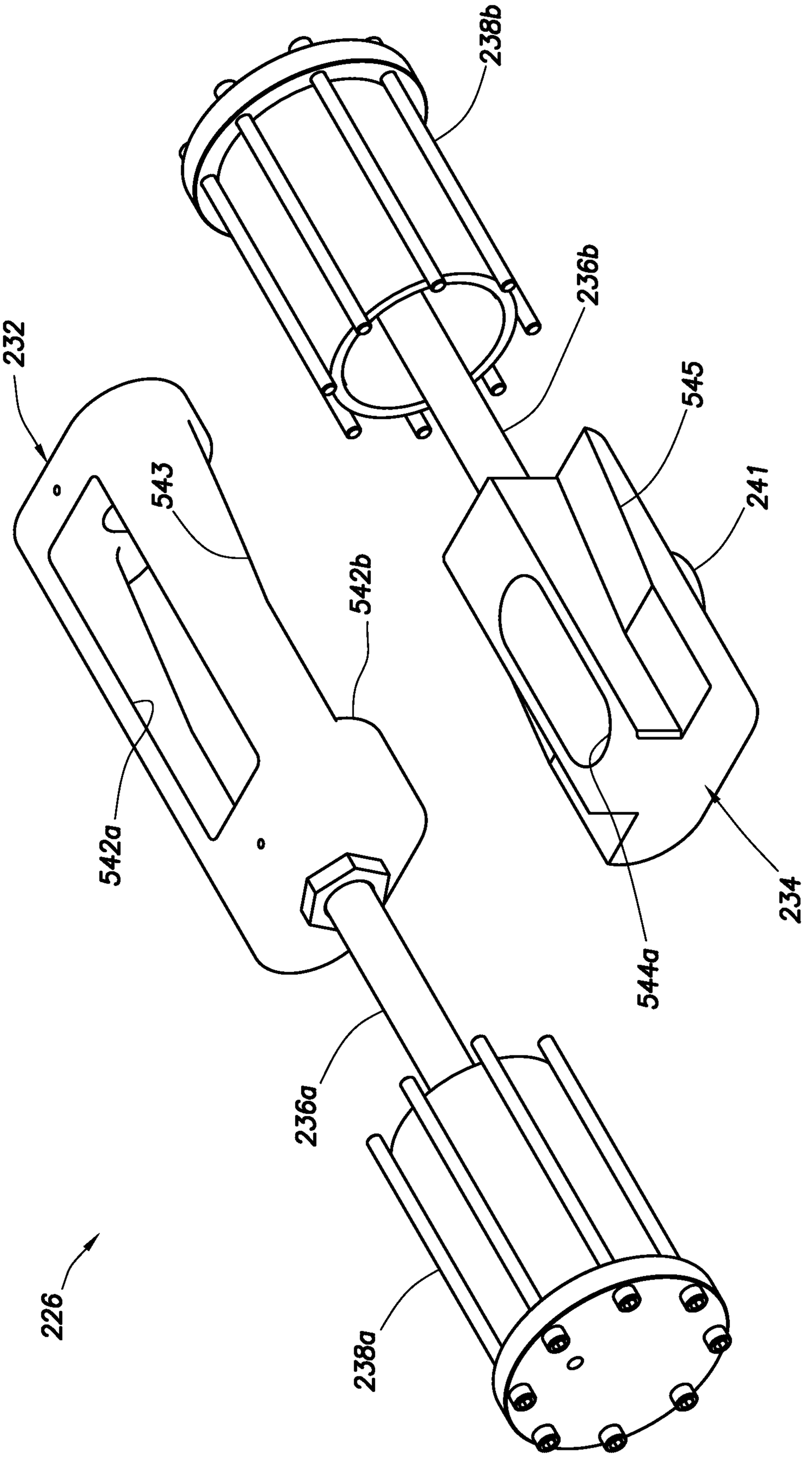


FIG.6A

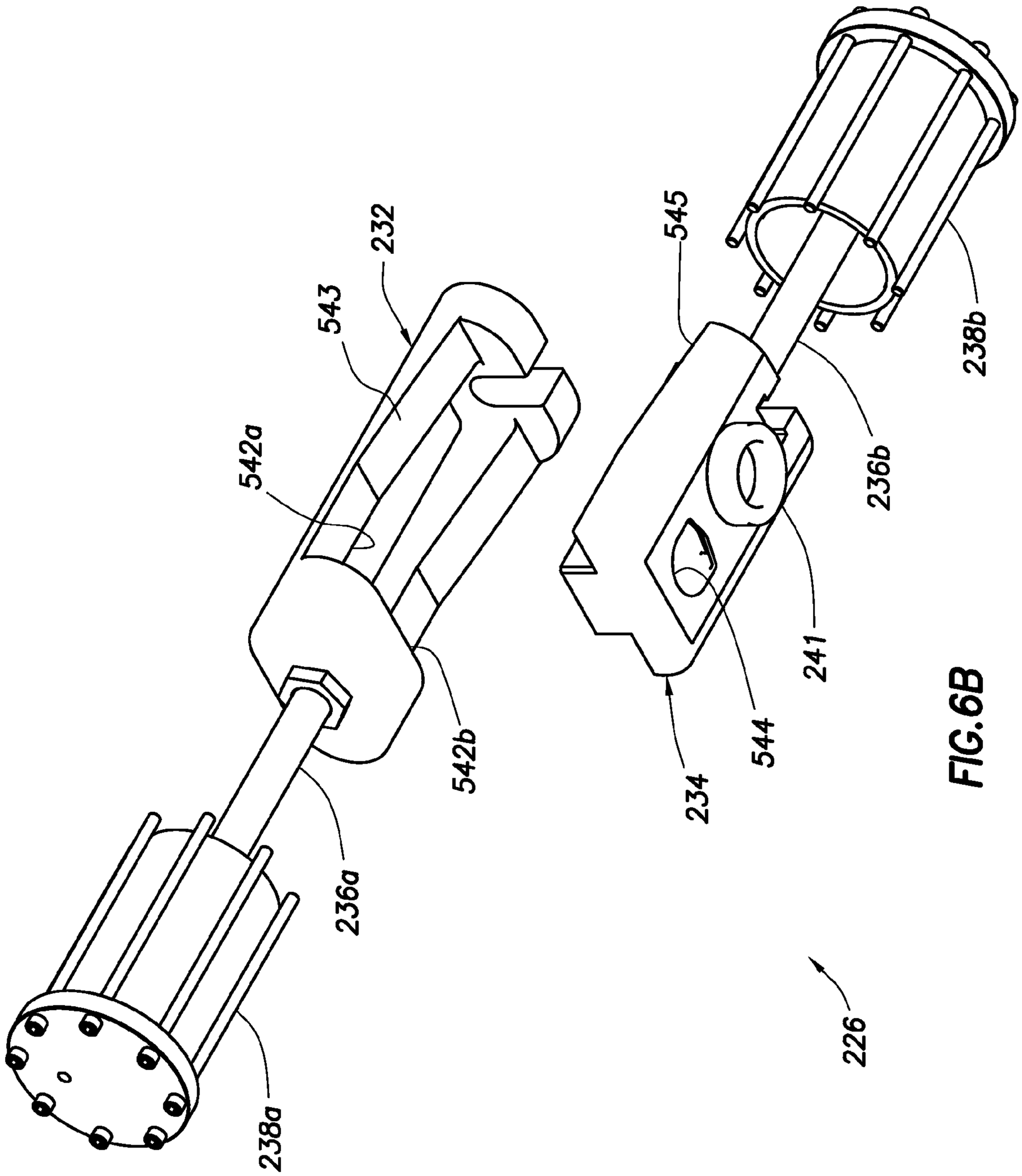
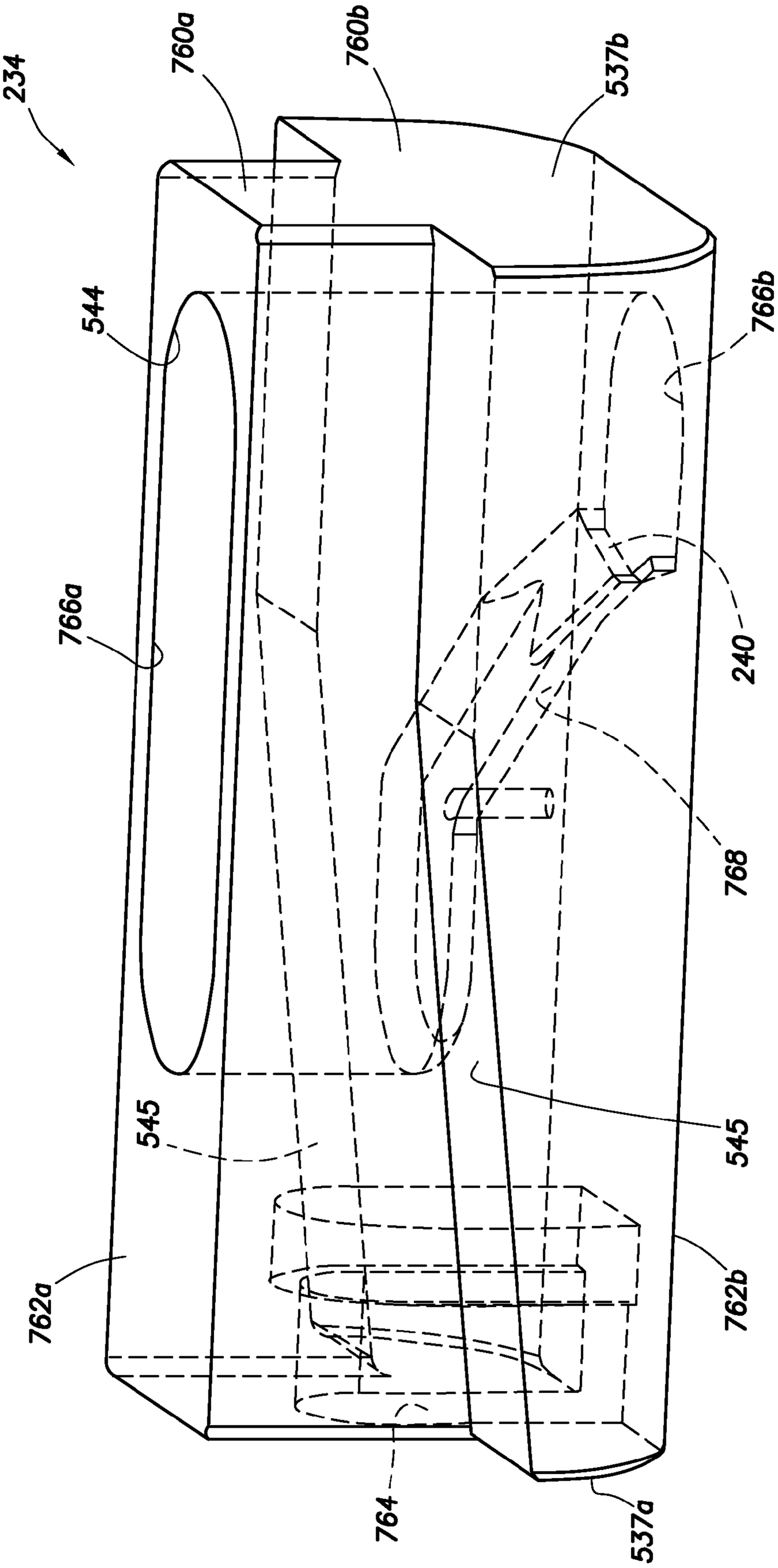


FIG.6B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240
768
545
545
762a
762b
764
537a

FIG.7

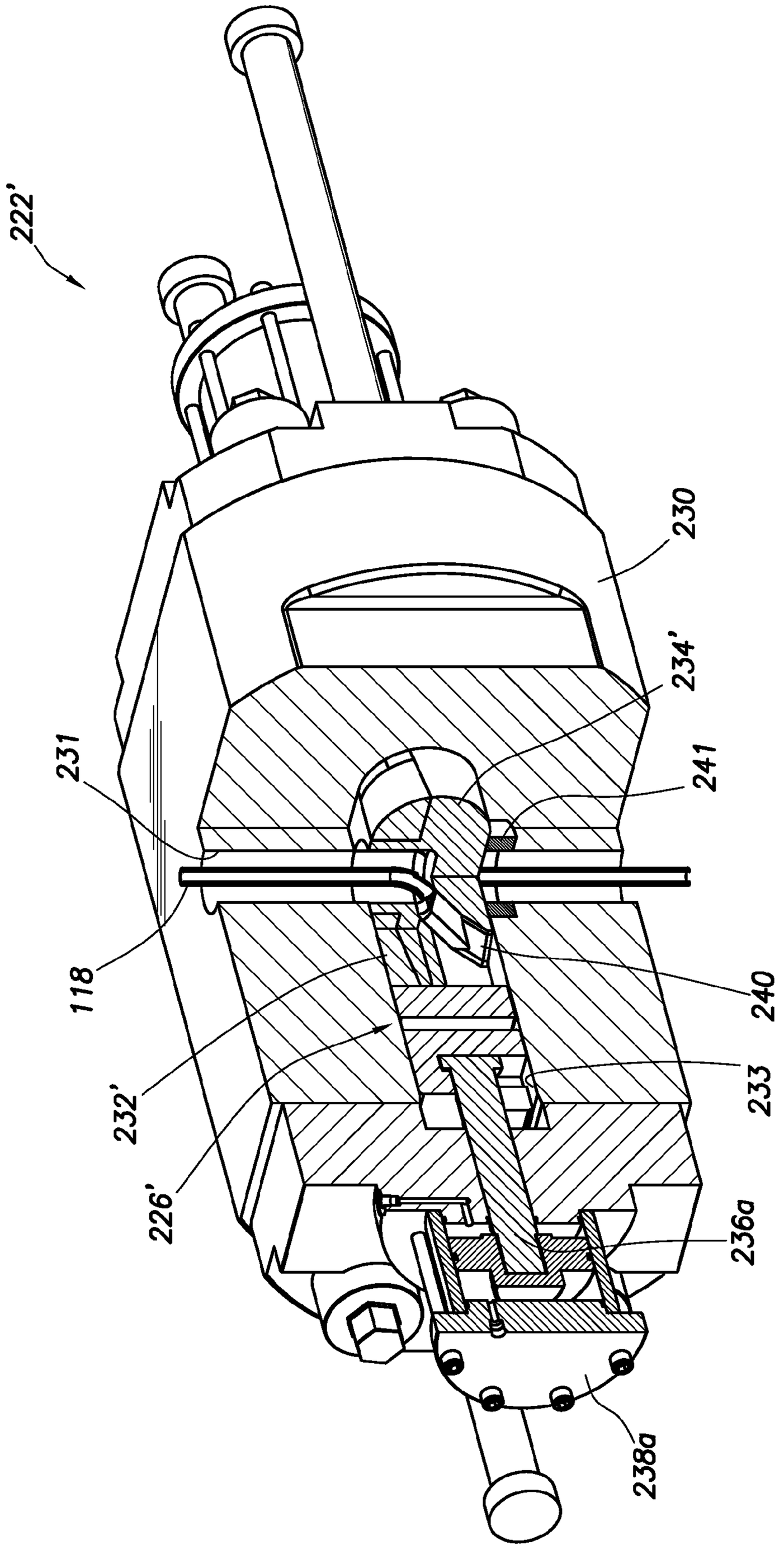


FIG.8

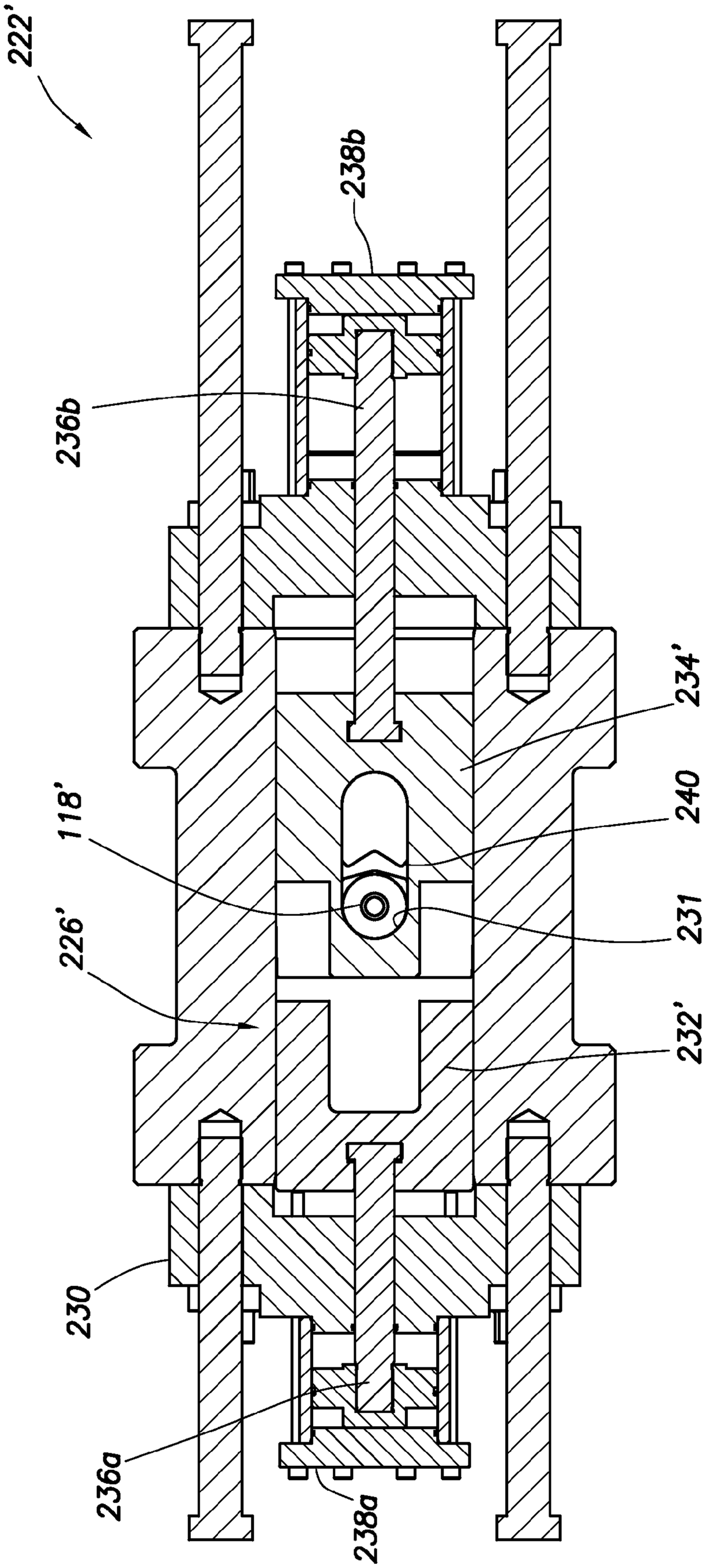


FIG.9A

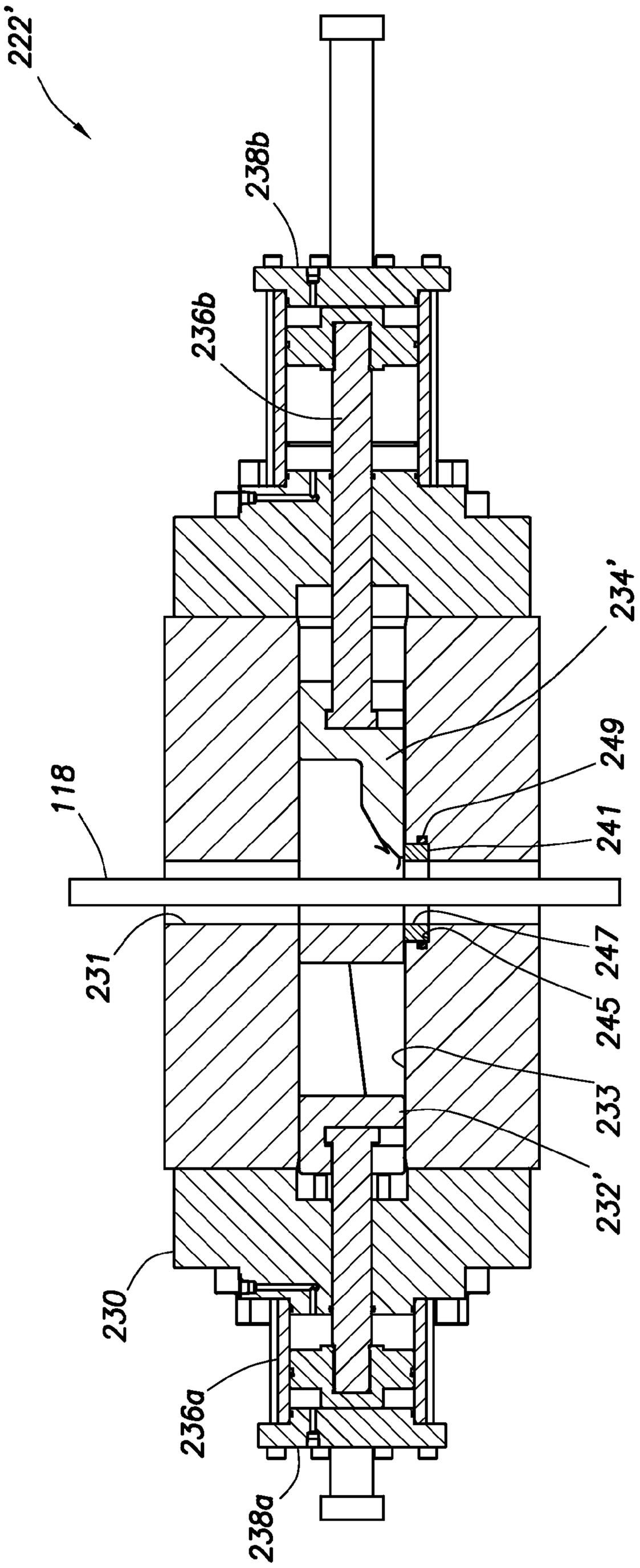


FIG.9B

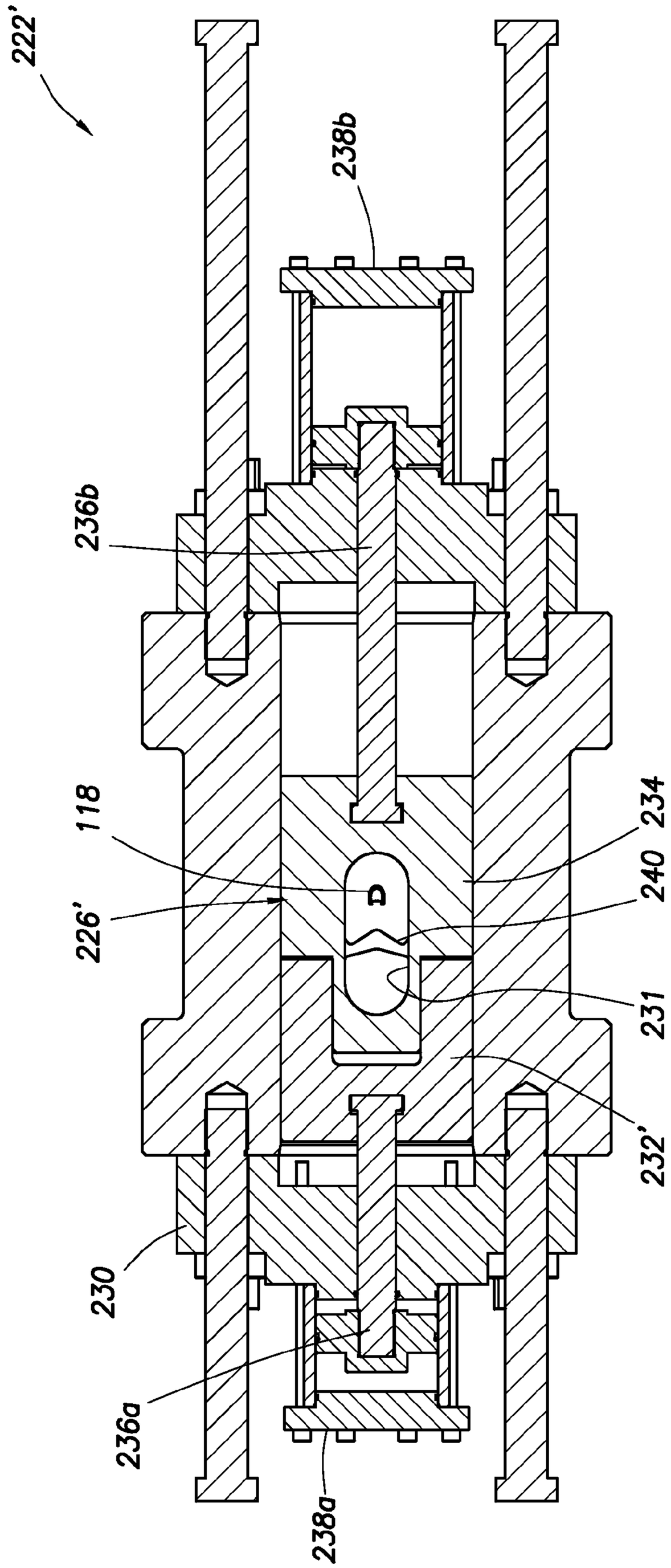


FIG. 10A

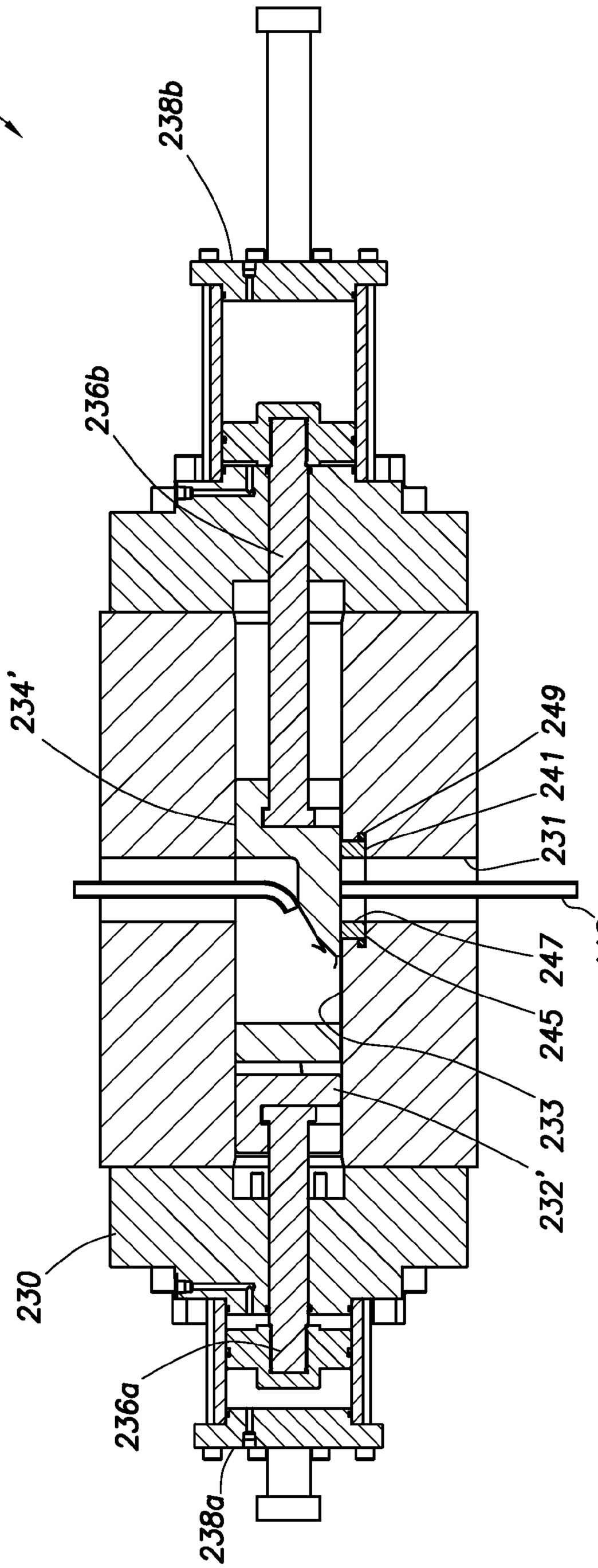
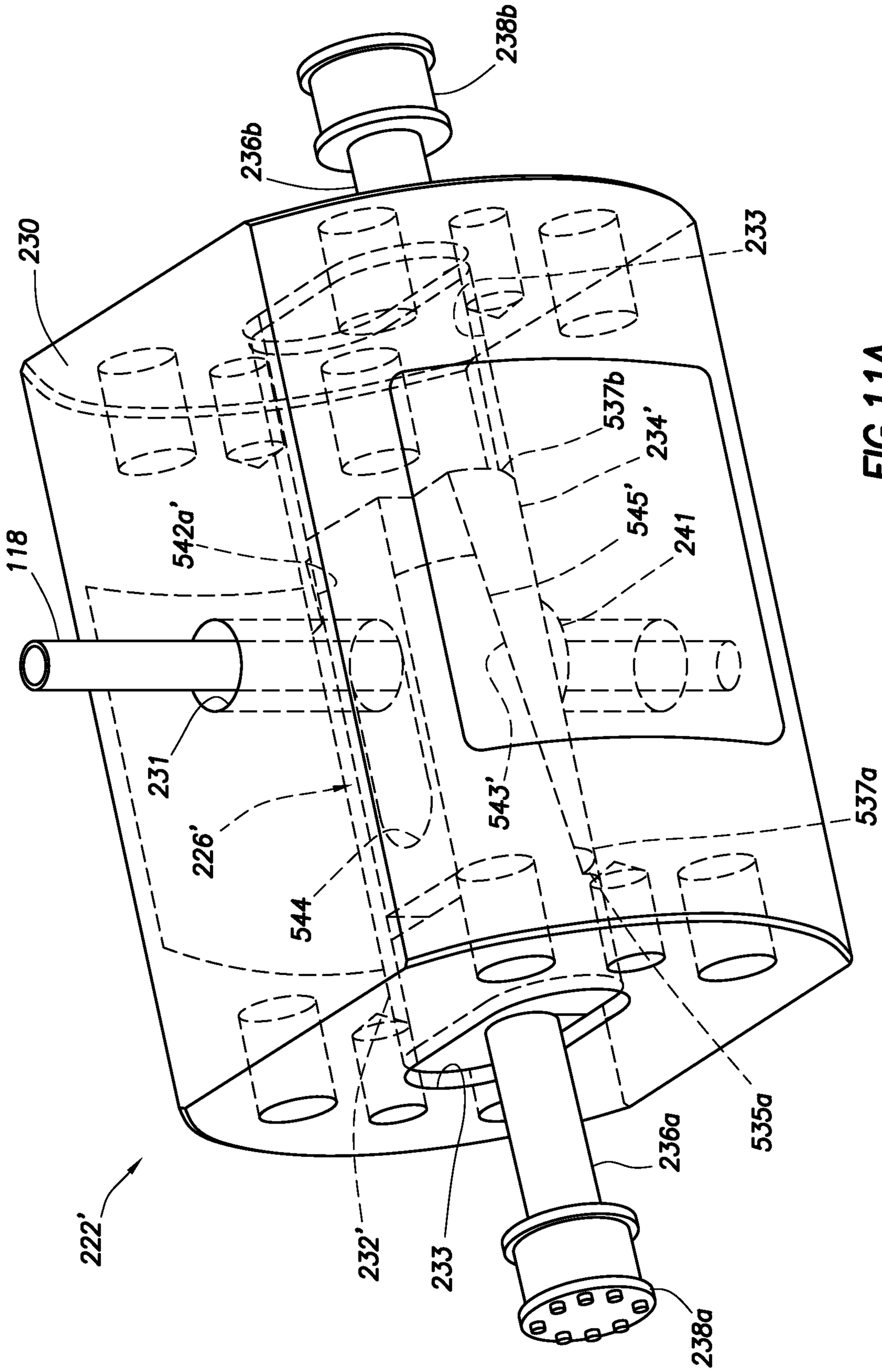


FIG. 10B


238b
236b
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234'
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543'
544
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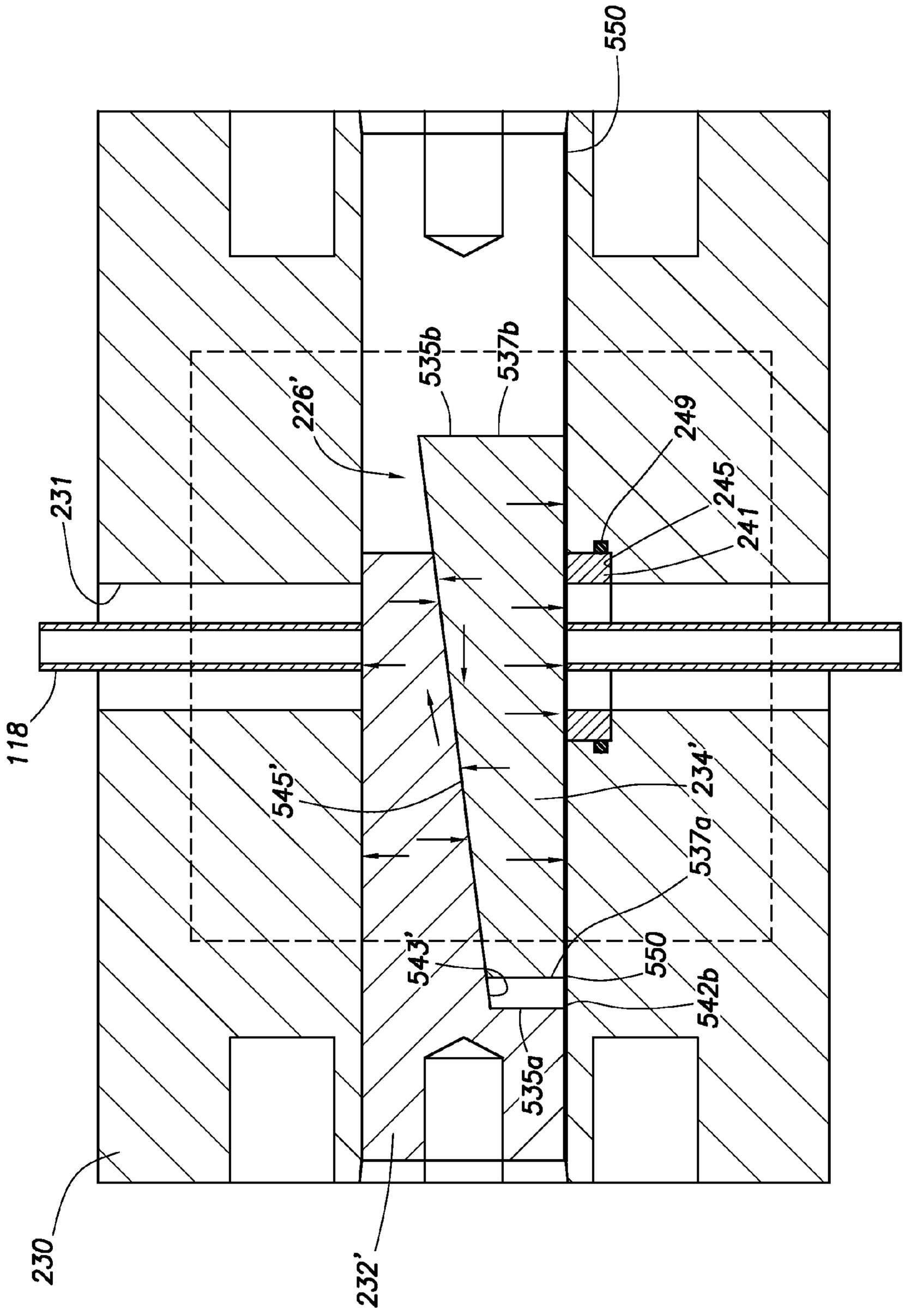
222'
232'
233
236a
535a
238a

FIG.11A


550
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542b
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232'

FIG.11B

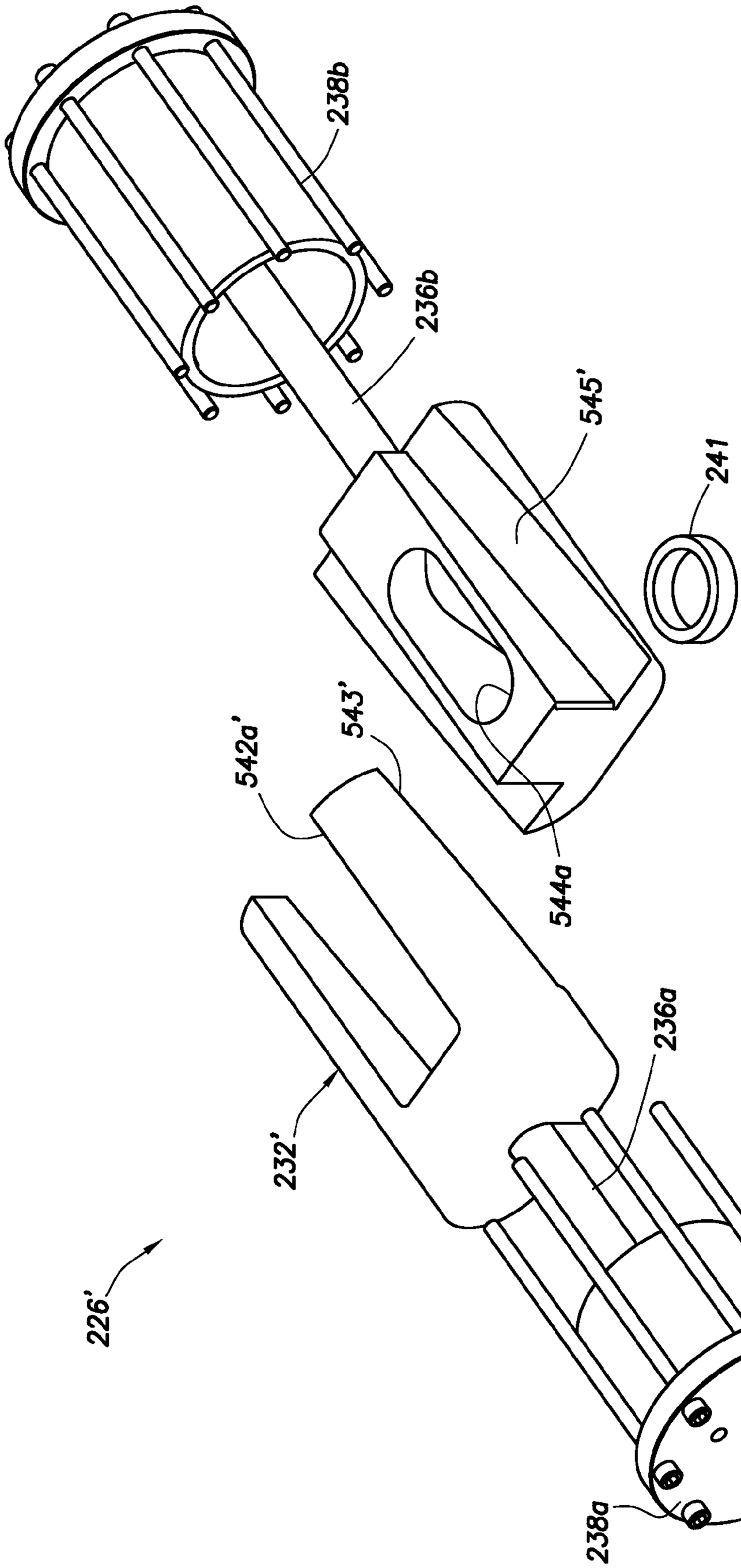


FIG. 12A

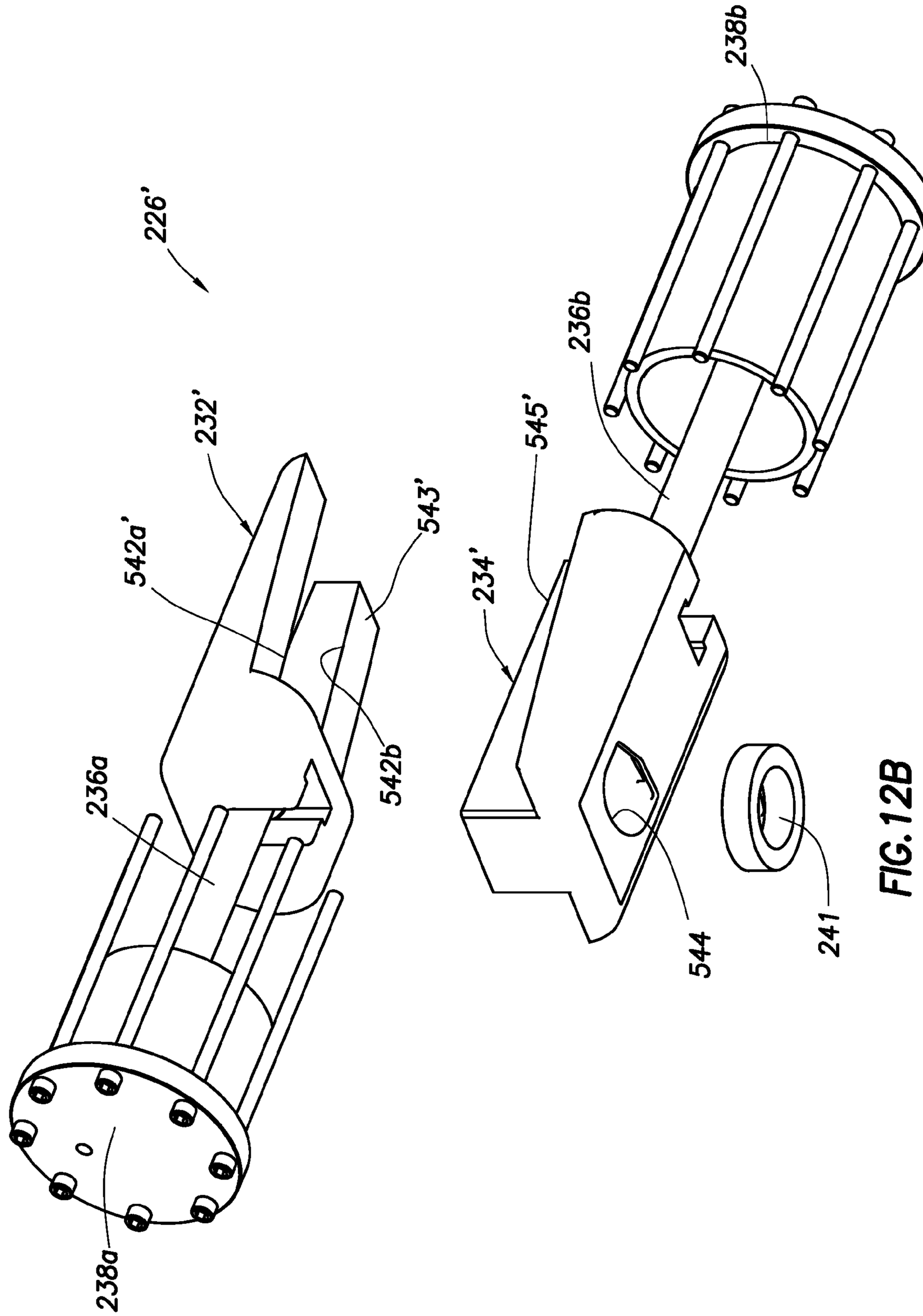
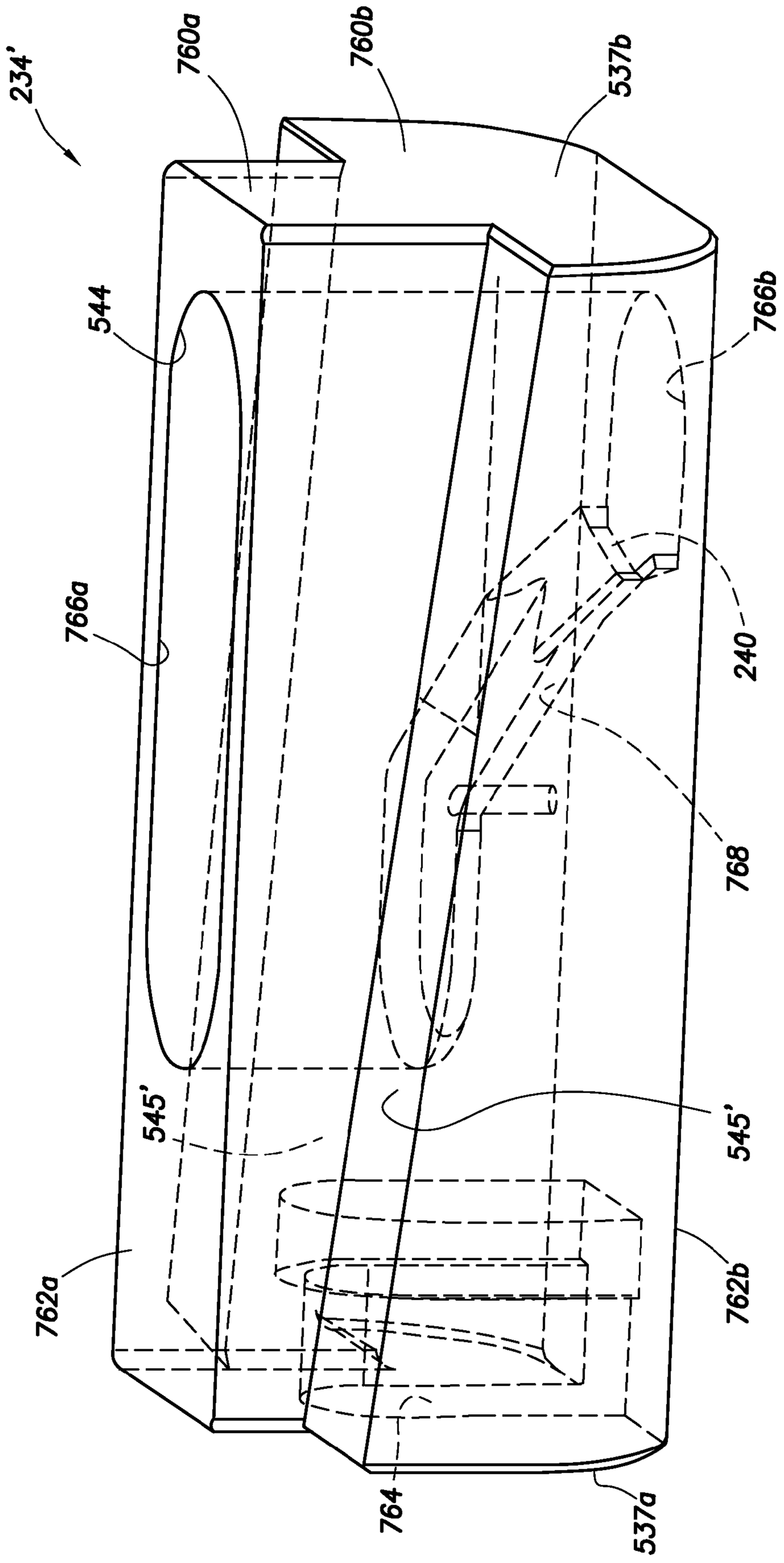


FIG.12B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545'
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762b
764
537a

FIG. 13

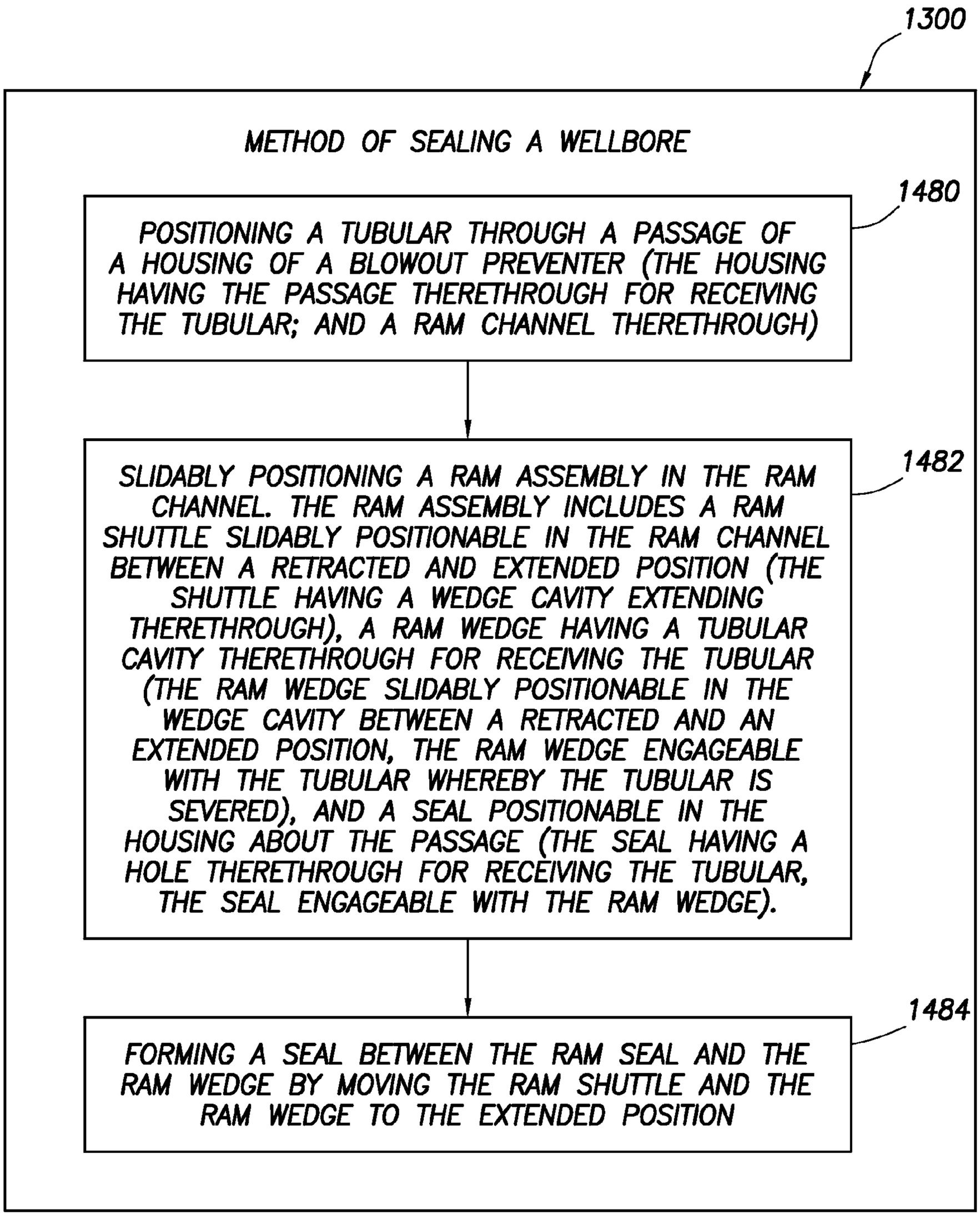
1300
METHOD OF SEALING A WELLBORE
1480
POSITIONING A TUBULAR THROUGH A PASSAGE OF A HOUSING OF A BLOWOUT PREVENTER (THE HOUSING HAVING THE PASSAGE THERETHROUGH FOR RECEIVING THE TUBULAR; AND A RAM CHANNEL THERETHROUGH)
1482
SLIDABLY POSITIONING A RAM ASSEMBLY IN THE RAM CHANNEL. THE RAM ASSEMBLY INCLUDES A RAM SHUTTLE SLIDABLY POSITIONABLE IN THE RAM CHANNEL BETWEEN A RETRACTED AND EXTENDED POSITION (THE SHUTTLE HAVING A WEDGE CAVITY EXTENDING THERETHROUGH), A RAM WEDGE HAVING A TUBULAR CAVITY THERETHROUGH FOR RECEIVING THE TUBULAR (THE RAM WEDGE SLIDABLY POSITIONABLE IN THE WEDGE CAVITY BETWEEN A RETRACTED AND AN EXTENDED POSITION, THE RAM WEDGE ENGAGEABLE WITH THE TUBULAR WHEREBY THE TUBULAR IS SEVERED), AND A SEAL POSITIONABLE IN THE HOUSING ABOUT THE PASSAGE (THE SEAL HAVING A HOLE THERETHROUGH FOR RECEIVING THE TUBULAR, THE SEAL ENGAGEABLE WITH THE RAM WEDGE).
1484
FORMING A SEAL BETWEEN THE RAM SEAL AND THE RAM WEDGE BY MOVING THE RAM SHUTTLE AND THE RAM WEDGE TO THE EXTENDED POSITION

FIG. 14

BLOWOUT PREVENTER WITH WEDGE RAM ASSEMBLY AND METHOD OF USING SAME

BACKGROUND

This present disclosure relates generally to techniques for performing wellsite operations. More specifically, the present disclosure relates to techniques for preventing blowouts involving, for example, sealing and/or severing a tubular of a wellbore.

Oilfield operations may be performed to locate and gather valuable downhole fluids. Oil rigs are positioned at wellsites, and downhole tools, such as drilling tools, are deployed into the ground to reach subsurface reservoirs. Once the downhole tools form a wellbore to reach a desired reservoir, casings may be cemented into place within the wellbore, and the wellbore completed to initiate production of fluids from the reservoir. Downhole tubular devices may be positioned in the wellbore to enable the passage of subsurface fluids to the surface.

Leakage of subsurface fluids may pose an environmental threat if released from the wellbore. Equipment, such as blow out preventers (BOPs), may be positioned about the wellbore to form a seal about a tubular therein to prevent leakage of fluid as it is brought to the surface. BOPs may have selectively actuatable rams, such as pipe rams or shear rams, that may be activated to seal and/or sever a tubular in a wellbore. Some examples of BOPs are provided in U.S. Patent/Application No. 2010/0319906, U.S. Pat. Nos. 3,235,224, 4,215,749, 4,671,312, 4,997,162, 7,975,761, and 8,353,338. BOPs may be subject to forces, such as wellbore pressure and mechanical forces.

SUMMARY

In at least one aspect, the present disclosure relates to a ram assembly of a blowout preventer for sealing a wellbore. The blowout preventer has a housing with a passage therethrough for receiving a tubular of the wellbore and a ram channel therethrough. The ram assembly includes a ram shuttle, a ram wedge and a ram seat. The ram shuttle is slidably positionable in the ram channel between a retracted and extended position, and has a wedge cavity extending therethrough and an inclined surface thereon. The ram wedge has a tubular cavity therethrough for receiving the tubular, is slidably positionable in the wedge cavity between a retracted and an extended position, and has a corresponding inclined surface engageable with the inclined surface of the ram shuttle to wedge between the ram shuttle and the housing of the blowout preventer whereby a force is generated therebetween. The ram wedge is engageable with the tubular whereby the tubular is severed. The ram seat is positionable in the housing about the passage. The ram seat has a hole therethrough for receiving the tubular, and is engageable with the ram wedge and the housing of the blowout preventer when the ram shuttle and the ram wedge are moved to the extended position whereby a seal is formed therebetween.

In the extended position the ram wedge may form a fluid barrier between the channel and the ram seat. The ram assembly may also include a blade positionable on the ram wedge and engageable with the tubular whereby the tubular is severed. The ram shuttle may have a closed end or an open end. The ram shuttle and the ram wedge may move in the same direction or in opposite directions.

The tubular cavity may have a first portion and a second portion with a tapered shoulder therebetween, the first portion larger than the second portion. The wedge cavity may have a first portion for receiving a first portion of the ram wedge, and the wedge cavity may have a second portion for receiving the second portion of the ram wedge, the second portion of the ram wedge may be wider than the first portion of the ram wedge.

The ram shuttle and the ram wedge may have corresponding inclined surfaces for sliding engagement therebetween. The ram assembly may also include a piston and a cylinder operatively connectable to the ram shuttle and/or a piston and a cylinder operatively connectable to the ram wedge for driving movement thereof. The ram seat may be a metal to metal seal. The ram assembly may also include at least one additional seal.

In another aspect, the present disclosure relates to a blowout preventer for sealing the wellbore. The blowout preventer includes a housing having a passage therethrough for receiving the tubular and a ram channel therethrough, and at least one ram assembly. The ram assembly may include a ram shuttle, a ram wedge and a ram seat. The ram shuttle is slidably positionable in the ram channel between a retracted and extended position. The ram shuttle has a wedge cavity extending therethrough and an inclined surface thereon. The ram wedge has a tubular cavity therethrough for receiving the tubular, is slidably positionable in the wedge cavity between a retracted and an extended position, and has a corresponding inclined surface engageable with the inclined surface of the ram shuttle to wedge between the ram shuttle and the housing of the blowout preventer whereby a force is generated therebetween, the ram wedge engageable with the tubular whereby the tubular is severed. The ram seat may be positionable in the housing about the passage. The ram seat has a hole therethrough for receiving the tubular. The ram seat is engageable with the ram wedge and the housing of the blowout preventer when the ram shuttle and the ram wedge are moved to the extended position whereby a seal is formed therebetween. The blowout preventer may also include at least one controller.

Finally, in another aspect, the present disclosure relates to a method for sealing a wellbore. The wellbore has a tubular extending therefrom for passing therethrough. The method involves providing the blowout preventer, positioning a tubular through the passage, the tubular cavity and the hole, and forming a seal between the ram seat and the ram wedge by moving the ram shuttle and the ram wedge to the extended position.

The forming may involve moving the ram wedge and the ram shuttle together, moving the ram wedge to a partially engaged position and then moving the ram wedge to fully engaged position by moving the ram shuttle to the engaged position, forming a fluid barrier between the channel and fluid in the wellbore, and/or generating a force by wedging the ram wedge between the ram shuttle and the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the above recited features and advantages of the present disclosure can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof that are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate example embodiments and are, therefore, not to be considered limiting of its scope. The figures are not necessarily to scale and certain features, and certain views of the figures may be shown exaggerated in scale or in schematic in the interest of clarity and conciseness.

FIG. **1** depicts a schematic view of an offshore wellsite having a blowout preventer (BOP) with a wedge ram assembly.

FIG. **2** is a partial cross-sectional view of a BOP with a wedge ram assembly.

FIGS. **3**A and **3**B are horizontal and longitudinal cross-sectional views, respectively of the BOP of FIG. **2** with the wedge ram assembly in an open position.

FIGS. **4**A and **4**B are horizontal and longitudinal cross-sectional views, respectively of the BOP of FIG. **2** with the wedge ram assembly in a closed position.

FIGS. **5**A and **5**B are perspective and plan views, respectively, partially transparent, of the BOP of FIG. **2** with the wedge ram assembly therein.

FIGS. **6**A and **6**B are top and bottom exploded views, respectively, of the wedge ram assembly of FIG. **5**A.

FIG. **7** is a perspective view of a ram wedge of the wedge ram assembly of FIG. **6**A.

FIG. **8** is a partial cross-sectional view of BOP with another wedge ram assembly.

FIGS. **9**A and **9**B are horizontal and longitudinal cross-sectional views, respectively of the BOP of FIG. **8** with another wedge ram assembly in an open position.

FIGS. **10**A and **10**B are horizontal and longitudinal cross-sectional views, respectively of the BOP of FIG. **8** with another wedge ram assembly in a closed position.

FIGS. **11**A and **11**B are perspective and plan views, respectively, partially transparent, of the BOP of FIG. **8** with the wedge ram assembly therein.

FIGS. **12**A and **12**B are top and bottom exploded views, respectively, of the wedge ram assembly of FIG. **11**A.

FIG. **13** is a perspective view of a ram wedge of the wedge ram assembly of FIG. **12**A.

FIG. **14** is a flow chart depicting a method of sealing a wellbore.

DETAILED DESCRIPTION

The description that follows includes exemplary apparatus, methods, techniques, and/or instruction sequences that embody techniques of the present subject matter. However, it is understood that the described embodiments may be practiced without these specific details.

Tubulars are positioned in a wellbore for passing fluids from downhole reservoirs to the surface during wellbore production. A blowout preventer (BOP) may be provided about the wellbore for receiving the tubular. The BOP has at least one ram slidably movable in the BOP for severing and/or sealing the tubular during a blowout. The ram assembly is configured with a ram shuttle that slidingly engages a ram wedge during operation. The ram wedge wedgingly engages the ram shuttle within a channel of the BOP and generates a mechanical force therebetween. As the mechanical forces are applied, the ram wedge presses on a ram seat positioned in the BOP and forms a seal (e.g., a metal-metal-seal) therewith. The ram wedge and the ram seat form a fluid barrier between the channel housing the ram assembly and the passage in the BOP that leads to the wellbore.

"Blowout preventers" as used herein relate to devices, such as well control packages, valves, gate valves, ram driven assemblies or other severing, sealing or restriction devices of varying sizes used to sever a tubular in a wellbore and/or to seal a wellbore and prevent leakage of fluid therefrom.

"Tubulars, "tubular devices" or "tubular strings" as used herein relates to pipes, certain downhole tools, casings, drill pipe, liner, coiled tubing, production tubing, wireline, slickline, or other tubular members positioned in the wellbore, and associated components, such as drill collars, tool joints, drill bits, logging tools, packers, and the like.

FIG. **1** depicts an offshore wellsite **100** with a BOP monitoring system **101**. While an offshore wellsite is depicted, the wellsite may be land based. The wellsite **100** has a surface system **102** and a subsea system **104**. The surface system **102** may include a rig **106**, a platform **108** (or vessel) and a surface unit **110**. The surface unit **110** may include one or more units, tools, controllers, processors, databases, etc., located at the platform **108**, a separate vessel, and/or near to or remote from the wellsite **100**.

The subsea system **104** includes a conduit **112** extending from the platform **108** to a sea floor **114**. The subsea system further includes a wellhead **116** with a tubular **118** extending into a wellbore **120**, a BOP **122** and a subsea unit **124**. As shown, the BOP **122** has a ram assembly **126** for shearing and/or sealing about the tubular **118** to seal the wellbore **120**. One or more BOPs **122**, ram assemblies **126** and associated equipment may be provided. The ram assembly **126** is a wedge ram assembly capable of generating a mechanical force for sealing as will be described further herein.

The surface system **102** and subsea system **104** may be provided with one or more units, such as surface unit **110** and/or subsea unit **124**, located at various locations to control the surface system **102** and/or the subsea systems **104**. Communication links **128** may be provided for communication between the units and various parts of the wellsite **100**. The BOP monitoring unit **101** may monitor operation of the BOP and collect data therefrom. This data may be communicated to the units.

FIG. **2** depicts a BOP **222** for severing a tubular **118**. The BOP includes a housing **230** with a ram assembly **226** therein. The ram assembly **226** has an integrated configuration. The tubular **118** is positioned in a passage **231** extending vertically through the BOP **222**. The ram assembly **226** is slidably positionable in a channel **233** extending horizontally through the BOP **222**. The channel **233** intersects the vertical passage **231** and is in selective fluid communication therewith. While one ram assembly **226** is depicted in one BOP housing **230**, one or more ram assemblies **226** may be positioned in one or more channels **233** in one or more BOP housings **230**.

The ram assembly **226** includes a ram shuttle **232**, a ram wedge **234**, a ram piston **236***a*, and a cylinder **238***a*. The ram shuttle **232** is operatively connectable to piston **236***a* and cylinder **238***a*. The ram wedge **234** is operatively connectable to piston **236***b* (not visible in this view, but shown in FIGS. **3**A-**4**B) and cylinder **238***b*. The ram wedge **234** may have a blade **240** for engaging the tubular **118**. The blade **240** may be a separate component, such as a sharp metal piece inserted into the ram wedge **234**. In some cases, no blade is provided. The blade **240** is drivable by movement of the wedge **234** such that the tubular **118** is severed as shown in FIG. **2**. The ram assembly **226** is shaped to engage the tubular **118** during operation and form a seal with a ram seat **241** in the housing **230** as will be described further herein.

FIGS. **3**A-**6**B depict various views of the BOP **222** and the ram assembly **226** depicting operation thereof. FIGS. **3**A and **3**B depict horizontal and vertical views, respectively of the BOP **222** in an open (or unactivated) position. In this position, the ram assembly **226** is retracted to a disengaged position, and ready to perform a severing and sealing operation. FIGS. **4**A and **4**B depict horizontal and vertical views, respectively of the BOP **222** in an closed (or activated) position. In this position, the ram assembly **226** is extended to the engaged position after performing a severing and sealing operation.

As also shown in FIGS. **3**A-**4**B, the BOP **222** includes a single ram assembly with dual pistons **236***a,b* and cylinders

238*a,b*. The ram shuttle **232** is driven by the piston **236***a* and cylinder **238***a*. The ram wedge **234** is driven by the piston **236***b* and cylinder **238***b*. The piston **236***a* may drive the ram shuttle **232** between the disengaged position of FIGS. **3**A and **3**B to the engaged position of FIGS. **4**A and **4**B. The ram wedge **234** may be driven by the piston **236***b* and cylinder **238***b* to a partially engaged position between the disengaged position of FIGS. **3**A and **3**B and the engaged position of FIGS. **4**A and **4**B.

In an example, initially, the ram wedge **234** is moved from a retracted position of FIGS. **3**A and **3**B a distance partially toward the engaged position of FIGS. **4**A and **4**B by activation of piston **236***b* and cylinder **238***b*. The piston **236***b* may have a stroke to define the travel of the ram wedge **234** such that it extends partially, fully or otherwise as desired between the disengaged and engaged positions. This primary movement of the ram wedge **234** may drive the blade **240** of the ram wedge **234** through the tubular **118** and sever the tubular into two portions. Once the ram wedge **234** is moved, the ram shuttle **232** may then be activated in a secondary motion by piston **236***a* and cylinder **238***a* to move to the engaged position of FIGS. **4**A and **4**B. As the ram shuttle **232** advances, it sliding engages the ram wedge **234** and pushes on the ram wedge **234**. This secondary movement of the ram wedge **234** by the ram shuttle **232** drives the ram wedge **234** to the fully engaged position of FIGS. **4**A and **4**B.

The ram seat **241** is positioned in a seal cavity **245** of the BOP **230**. The ram seat **241** has an aperture **247** therethrough for fluid communication with passage **231**. The sliding engagement of the ram shuttle **232** and ram wedge **234** provides mechanical interaction therebetween to generate forces for sealing against ram seat **241** as will be described further herein.

The ram seat **241** may be a metal seal capable of generating a metal to metal seal with the ram wedge **234**. The ram seat **241** may optionally be made of other materials, such as elastomers, rubbers, etc. Additional seals **249** (or gaskets or other fluid restriction devices) may be positioned about the ram seat **241** for securing the ram seat in place and/or preventing the passage of fluid thereabout.

FIGS. **5**A-**6**B depict additional views of the BOP **222** and ram assembly **226**. As shown in FIG. **5**A, the BOP housing **230** is transparent to show the ram assembly **226** positioned in channel **233** in the engaged position. As shown in FIG. **5**B, a portion of the BOP housing **230** is depicted as transparent to show the ram assembly **226** in sealing engagement with ram seat **241**. FIGS. **6**A and **6**B depict top and bottom, respectively, exploded views of the ram assembly **226**.

The ram shuttle **232** is depicted as having a first cavity **542***a* for receiving a first portion of the ram wedge **234** and a second cavity **542***b* for receiving a second portion of the ram wedge **234**. In this integrated configuration, a portion of the ram wedge **234** is maintained within the ram shuttle **232** during operation. The ram shuttle **232** also has a wedge surface **543** for slidable engagement with a shuttle surface **545** of the ram wedge **234**. The ram shuttle **232** also has drive surfaces **535***a,b* for engagement with ends **537***a,b* of the ram wedge **234**. The ram wedge **234** has a tubular cavity **544** for receiving the tubular **118**.

The ram shuttle **232** is slidably engageable with the ram wedge **234**. The wedge surface **543** and the shuttle surface **545** are corresponding inclined surfaces for slidable movement therealong. With the ram wedge **234** partially moved to the engaged position, the ram shuttle **234** may then be advanced along the ram wedge **234** by activation of piston **236***a* and cylinder **238***a* as indicated by the left arrow.

The ram shuttle **232** and ram wedge **234** mechanically interact as the shuttle surface **545** of the ram wedge **234** is advanced along the wedge surface **543** of the shuttle **232**. The ram wedge **234** wedges between the ram shuttle **232** and the housing **230** thereby creating a force therebetween. The forces press the ram shuttle **232** and the ram wedge **234** together and against ram seat **241** and housing **230** as indicated by the arrows.

The forces between the ram wedge **234** and the ram seat **241** create a seal defining a fluid barrier **550** therebetween. The ram assembly **226** utilizes an outside applied force in combination with an angled ram wedge **234** to create the closing force required to affect a metal to metal seal about the BOP **222**. This seal isolates well flow through the passage **231** and prevents fluid from entering the channel **233** of the BOP **222**.

As the ram wedge **234** is moved to a partially and/or fully engaged position, anything (e.g., tubular **118**) in the wellbore is sheared. The ram shuttle **232** then advances to the engages position until the angled surfaces on both the ram shuttle **232** and the ram wedge **234** meet. The interfering inclined surfaces **543**, **545** create vertical movement between the ram shuttle **232** and the ram wedge **234**. The ram wedge **234** pushes the ram shuttle **232** in a direction away from the ram seat such that the ram shuttle **232** contacts the housing **230** along an upper portion of the channel **233**. The ram wedge **234** is also forced against the ram seat **241** such that the ram seat **241** is thereby forced against the seal pocket **245** in the housing **230**. The force generated between the ram assembly **226**, ram seat **241**, and seal pocket **245** in the housing **230** may create a metal to metal seal at two points. A first seal is created between the ram assembly **226** and the ram seat **241**. A second seal is created between the ram seat **241** and the seal pocket **245** in the housing **230**. Due to the geometry of the assembly these two seals may each define a metal to metal seal that effectively isolates the wellbore outside of the channel **233**.

While wellbore pressure Pw may be present (see, e.g., FIG. **5**B), the ram assembly **226** does not require wellbore pressure to form the fluid barrier **550**. Elastomers or other seals **249** are also not required (but optionally may be present) to seal or to assist in moving the seal assembly **226** to a sealed position.

Referring to FIG. **7**, the ram wedge **234** is shown in greater detail. As shown in this view, the ram wedge **234** has an inverted-T shaped body including a first portion **760***a* and a second portion **760***b*. The ram wedge **234** has a receptacle **764** for receiving the piston **236***b*. Tubular cavity **544** has an elongate opening **766***a* extending through first surface **762***a*, and a reduced opening **766***b* extending through second, opposite surface **762***b* of ram wedge **234**. A shoulder **768** extends between the elongate opening **766***a* and the reduced opening **766***b* to provide an inclined transition therebetween. Blade **240** (if provided) is positioned along a slanted portion of the shoulder **768** adjacent reduced opening **766***b*.

Referring to FIGS. **4**B and **7**, the first portion **760***a* of ram wedge **234** is slidingly receivable in the first ram cavity **542***a* of the ram shuttle **232**. The second portion **760***b* is positionable in a second cavity **542***b* of the ram shuttle **232**. First and second surfaces **762***a,b* of ram wedge **234** are slidingly engageable with the BOP housing **230**.

The shuttle surfaces **545** are positioned on opposite sides of the first portion **760***a*. A portion of the shuttle surfaces **545** may be inclined and a portion may be horizontal to define a travel path for movement of the ram shuttle **232** relative to the ram wedge **234**. Ends **537***a,b* of ram wedge **234** are engageable with the ram shuttle **232** for receiving the sliding forces thereof.

The tubular **118** is receivable through elongate opening **766***a* and reduced opening **766***b* of tubular cavity **544**. When present, the blade **240** is positioned such that, when the ram wedge **234** is advanced to the engaged position, the blade **240** engages and severs the tubular **118**. As the tubular **118** is severed, the tubular **118** rests against the inclined portion of shoulder **768**. The elongate opening **766** provides room for receiving the tubular **118** as the ram wedge **234** advances to the engaged position.

The bottom surface **762***b* adjacent reduced opening **766***b* provides a solid surface for covering passage **231** and hole **247** about the ram seat **241**, and preventing fluid flow therethrough. The mechanical forces resulting from engagement between the ram shuttle **232** and ram wedge **234** within the channel **233** press against ram seat **241** to create a seal and provide the fluid barrier **550** therebetween. The fluid barrier **550** prevents fluid from the wellbore from passing through passage **231** from below the ram seat **241** and into the channel **233** where moving parts of the ram assembly **226** are located.

The ram assembly **226** provided herein is depicted in a specific orientation and configuration. However, variations are possible. For example, the ram assembly **226** may be inverted within the ram channel **233**. Only one ram seat **241** is depicted, but one or more ram seats may be provided. For example, a ram seat **241** may be located upstream and/or downstream of the ram assembly **226**, and may be engageable by one or more ram assemblies **226**. The ram assembly **226** is depicted in a gate valve type configuration with a single ram wedge, but could include one or more gate, opposing or other type of rams.

The ram assembly **226** is depicted as providing a metal to metal seal that isolates fluid flow and prevents fluid from the wellbore from entering cavity **233**. The seal is depicted as being driven by mechanical forces resulting from activation of the ram shuttle **232** and ram wedge **234**. The seal formed by the ram assembly **226** may also employ other forces, such as wellbore pressure, but does not need such additional forces to generate the necessary closing force to affect the seal and create the fluid barrier.

FIG. **8** depicts a modified BOP **222'** for severing a tubular **118**. The BOP **222'** is the same as BOP **222** as previously described, except that the ram assembly **226'** has a different configuration. The ram assembly **226'** includes a modified ram shuttle **232'** separate from and engageable with a modified ram wedge **234'**. In this version, the ram assembly **226'** has a separate configuration. Since the ram shuttle has an open end **970**, the end **535***b* of ram shuttle **232'** is removed and end **537***b* of ram wedge **234** engages the housing **230** rather than ram wedge **537***b*. The modified ram shuttle **232'** is open ended to slidingly receive the modified ram wedge **234'**.

FIGS. **9**A-**10**B depict various views of the BOP **222'** and the ram assembly **226'** depicting operation thereof. FIGS. **9**A and **9**B depict horizontal and vertical cross-sectional views, respectively of the BOP **222'** in an open (or unactivated) position. In this position, the ram assembly **226'** is retracted to a disengaged position, and ready to perform a severing and sealing operation. FIGS. **10**A and **10**B depict horizontal and vertical cross-sectional views, respectively of the BOP **222'** in a closed (or activated) position. In this position, the ram assembly **226'** is extended to the engaged position after performing a severing and sealing operation.

As shown in FIGS. **9**A-**10**B, the ram assembly **226'** is the same as ram assembly **226**, except that the ram shuttle **232'** and ram assembly **234'** have been modified for independent movement. The ram shuttle **232'** is the same as ram shuttle **232**, except that the ram shuttle has an open end **970** for receiving the ram wedge **234**. The ram shuttle **232'** is slidably movable in cavity **233** via piston **236***a* and cylinder **238***a* and the ram wedge **234'** is slidably movable in cavity **233** via piston **236***b* and cylinder **238***b* as previously described, but in a different sequence. In this operation, the ram shuttle **232'** and the ram wedge **234'** move towards each other from the disengaged position of FIGS. **9**A and **9**B to the engaged position of FIGS. **10**A and **10**B.

In an example operation, the ram wedge **234'** is advanced to a partially engaged position by activation of piston **236***b* and cylinder **238***b*. In this primary movement, the ram wedge **234'** severs the tubular. The ram shuttle **232'** may then advance to the engaged position by moving towards the ram wedge **234'** by activation of piston **236***a* and cylinder **236***a*. The piston **236***b* and cylinder **238***b* may continue to apply a force to prevent retraction of the ram wedge **234'**.

FIGS. **11**A-**13** show the modified ram assembly **226'** in greater detail. FIGS. **11**A and **11**B show the ram assembly **226'** in BOP housing **230**. FIGS. **12**A and **12**B show exploded views of the ram assembly **226'**. FIG. **13** shows a detailed view of the modified ram wedge **234'**. As shown in these figures, the ram wedge **234'** and ram shuttle **232'** have modified inclined surfaces **543'**, **545'** for slidable engagement therebetween.

The modified ram shuttle **234'** is receivable by a modified upper portion **542***a* of the wedge cavity **544** as the ram shuttle **234'** and the ram wedge **232'** move together. The ram wedge **234'** slidingly engages the ram shuttle **232'**. While the movement between the ram wedge **234'** and the ram shuttle **232'** is different, the ram wedge **234'** wedges between the ram shuttle **234'** and the housing **230** to generate a mechanical force as previously described.

As shown in FIG. **13**, the inclined surface **545'** has been modified to incline in the reverse direction from the inclined surface **545** previously described. The inclined surface **545'** is also inclined along the entire length of ram wedge **234'**. As shown in FIGS. **11**A-**12**B, ram shuttle **232'** has a corresponding inclined surface **543'**.

FIG. **14** provides a method **1300** of sealing a wellbore. The method **1300** involves (**1480**) positioning a tubular through a passage of a housing of a blowout preventer (the housing having the passage therethrough for receiving the tubular; and a ram channel therethrough). The method also involves (**1482**) slidably positioning a ram assembly in the ram channel. The ram assembly includes a ram shuttle slidably positionable in the ram channel between a retracted and extended position (the shuttle having a wedge cavity extending therethrough), a ram wedge having a tubular cavity therethrough for receiving the tubular (the ram wedge slidably positionable in the wedge cavity between a retracted and an extended position, the ram wedge engageable with the tubular whereby the tubular is severed), and a seal positionable in the housing about the passage (the seal having a hole therethrough for receiving the tubular, the seal engageable with the ram wedge). The method continues by (**1484**) forming a seal between the ram seat and the ram wedge by moving the ram shuttle and the ram wedge to the extended position.

The forming may be achieved by moving the ram shuttle and ram seal in the same direction, in opposing directions, independently, integratedly and combinations thereof. The methods may be performed in any order, or repeated as desired. Various combinations of the methods may also be provided.

It will be appreciated by those skilled in the art that the techniques disclosed herein can be implemented for automated/autonomous applications via software configured with algorithms to perform the desired functions. These aspects can be implemented by programming one or more suitable

general-purpose computers having appropriate hardware. The programming may be accomplished through the use of one or more program storage devices readable by the processor(s) and encoding one or more programs of instructions executable by the computer for performing the operations described herein. The program storage device may take the form of, e.g., one or more floppy disks; a CD ROM or other optical disk; a read-only memory chip (ROM); and other forms of the kind well known in the art or subsequently developed. The program of instructions may be "object code," i.e., in binary form that is executable more-or-less directly by the computer; in "source code" that requires compilation or interpretation before execution; or in some intermediate form such as partially compiled code. The precise forms of the program storage device and of the encoding of instructions are immaterial here. Aspects of the invention may also be configured to perform the described functions (via appropriate hardware/software) solely on site and/or remotely controlled via an extended communication (e.g., wireless, internet, satellite, etc.) network.

While the embodiments are described with reference to various implementations and exploitations, it will be understood that these embodiments are illustrative and that the scope of the inventive subject matter is not limited to them. Many variations, modifications, additions and improvements are possible. For example, one or more wedge ram assemblies with one or more rams may be provided in one or more orientations within a housing of the BOP.

Plural instances may be provided for components, operations or structures described herein as a single instance. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within the scope of the inventive subject matter.

What is claimed is:

1. A ram assembly of a blowout preventer for sealing a wellbore, the blowout preventer having a housing with a passage therethrough for receiving a tubular of the wellbore and a ram channel therethrough, the ram assembly comprising:

a ram shuttle slidably positionable in the ram channel between a retracted and extended position, the ram shuttle having a wedge cavity extending therethrough and an inclined surface thereon;

a ram wedge having a tubular cavity therethrough for receiving the tubular, the ram wedge slidably positionable in the wedge cavity between a retracted and an extended position, the ram wedge having a corresponding inclined surface engageable with the inclined surface of the ram shuttle to wedge between the ram shuttle and the housing of the blowout preventer whereby a force is generated therebetween, the ram wedge engageable with the tubular; and

a ram seat positionable in the housing about the passage, the ram seat having a hole therethrough for receiving the tubular, the ram seat engageable with the ram wedge and the housing of the blowout preventer when the ram shuttle and the ram wedge are moved to the extended position whereby a seal is formed therebetween.

2. The ram assembly of claim **1**, wherein in the extended position the ram wedge forms a fluid barrier between the channel and the ram seat.

3. The ram assembly of claim **1**, further comprising a blade positionable on the ram wedge and engageable with the tubular whereby the tubular is severed.

4. The ram assembly of claim **1**, wherein the ram shuttle has a closed end.

5. The ram assembly of claim **1**, wherein the ram shuttle has an open end.

6. The ram assembly of claim **1**, wherein the ram shuttle and the ram wedge move in the same direction.

7. The ram assembly of claim **1**, wherein the ram shuttle and the ram wedge move in opposite directions.

8. The ram assembly of claim **1**, wherein the tubular cavity has a first portion and a second portion with a tapered shoulder therebetween, the first portion larger than the second portion.

9. The ram assembly of claim **1**, wherein the wedge cavity has a first portion for receiving a first portion of the ram wedge and wherein the wedge cavity has a second portion for receiving the second portion of the ram wedge, the second portion of the ram wedge being wider than the first portion of the ram wedge.

10. The ram assembly of claim **1**, wherein the ram shuttle and the ram wedge have corresponding inclined surfaces for sliding engagement therebetween.

11. The ram assembly of claim **1**, further comprising a piston and a cylinder operatively connectable to the ram shuttle for driving movement thereof.

12. The ram assembly of claim **1**, further comprising a piston and a cylinder operatively connectable to the ram wedge for driving movement thereof.

13. The ram assembly of claim **1**, wherein the ram seat is a metal to metal seal.

14. The ram assembly of claim **1**, further comprising at least one additional seal.

15. A blowout preventer for sealing a wellbore, the wellbore having a tubular extending therefrom for passing therethrough, comprising:

a housing having a passage for receiving the tubular and a ram channel therethrough; and

at least one ram assembly, comprising:

a ram shuttle slidably positionable in the ram channel between a retracted and extended position, the ram shuttle having a wedge cavity extending therethrough and an inclined surface thereon;

a ram wedge having a tubular cavity therethrough for receiving the tubular, the ram wedge slidably positionable in the wedge cavity between a retracted and an extended position, the ram wedge having a corresponding inclined surface engageable with the inclined surface of the ram shuttle to wedge between the ram shuttle and the housing of the blowout preventer whereby a force is generated therebetween, the ram wedge engageable with the tubular; and

a ram seat positionable in the housing about the passage, the ram seat having a hole therethrough for receiving the tubular, the ram seat engageable with the ram wedge and the housing of the blowout preventer when the ram shuttle and the ram wedge are moved to the extended position whereby a seal is formed therebetween.

16. The blowout preventer of claim **15**, further comprising at least one controller.

17. A method for sealing a wellbore, the wellbore having a tubular extending therefrom for passing therethrough, comprising:

providing a blowout preventer comprising:

a housing having a passage and a ram channel therethrough; and

at least one ram assembly, comprising:

a ram shuttle slidably positionable in the ram channel between a retracted and extended position, the ram shuttle having a wedge cavity extending therethrough and an inclined surface thereon;

a ram wedge having a tubular cavity therethrough for receiving the tubular, the ram wedge slidably positionable in the wedge cavity between a retracted and an extended position, the ram wedge having a corresponding inclined surface engageable with the inclined surface of the ram shuttle to wedge between the ram shuttle and the housing of the blowout preventer whereby a force is generated therebetween, the ram wedge engageable with the tubular; and

a ram seat positionable in the housing about the passage, the ram seat having a hole therethrough for receiving the tubular, the ram seat engageable with the ram wedge and the housing of the blowout preventer when the ram shuttle and the ram wedge are moved to the extended position whereby a seal is formed therebetween; and

positioning a tubular through the passage, the tubular cavity and the hole; and

forming a seal between the ram seat and the ram wedge by moving the ram shuttle and the ram wedge to the extended position.

18. The method of claim **17**, wherein the forming comprises moving the ram wedge and the ram shuttle together.

19. The method of claim **17**, wherein the forming comprises moving the ram wedge to a partially engaged position and then moving the ram wedge to fully engaged position by moving the ram shuttle to the engaged position.

20. The method of claim **17**, wherein the forming comprises forming a fluid barrier between the channel and fluid in the wellbore.

21. The method of claim **17**, wherein the forming comprises generating a force by wedging the ram wedge between the ram shuttle and the housing.

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